An Investigation of Incompleteness of List Frames in U.S. Agricultural Surveys

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AN INVESTIGATION OF INCOMPLETENESS OF LIST FRAMES IN U.S. AGRICULTURAL SURVEYS by Raj S. Chhikara[1], Floyd M. Spears[2] and Charles R. Perry. Sampling and Estimation Research Section, Research Division, National Agricultural Statistics Service, United States Department of Agriculture, Washington DC 20250-2000, Report No. RD-99-03, July, 1999.

ABSTRACT

An evaluation is made of the NASS multiple frame (MF) survey estimator and a simple ratio estimator for various agricultural items using operational estimates from various quarterly agricultural surveys between June 1992 and May 1997. The relative mean deviation (R-MD) from the official statistics and the relative root mean square deviation (R-RMSD) from the official statistics were used as the performance criteria for each estimator. More specifically, the effect of the list frame coverage (which at the time of this analysis did not incorporate agricultural census records) on the R-RMSD and R-MD of these estimators is investigated. The empirical evaluations show that the R-RMSD tends to increase for both estimators when the list coverage is below eighty percent. The performance of the MF estimator is similar for the base and non-base survey periods for most items, and the ratio estimator performs similarly to the MF estimator when the list coverage exceeds eighty-five percent.

KEY WORDS

Multiple Frame Estimator; Ratio Estimator; List Frame Coverage; Relative Mean Deviation; Relative Root Mean Squared Deviation

ACKNOWLEDGEMENTS

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SUMMARY

This report summarizes an evaluation made of the performance of NASS multiple frame (MF) survey estimators and that of a ratio estimator for various agricultural items as a function of the level of list frame coverage using surveys made prior to the inclusion of agricultural census records. The list frame for these surveys is incomplete, requiring that additional information be collected using an area frame. The level of coverage of the list frame can vary substantially at the state and regional level for some agricultural items. Part of the motivation for looking at the performance as a function of list coverage is to determine whether or not the performance of the ratio estimator would be comparable to that of the MF survey estimator at some identifiable level of list coverage.

The quarterly estimates and official statistics were obtained for all quarters available for various labor items from June, 1992 to April, 1996. and for various crop and hog items from June, 1993 to December, 1997. No algorithm or procedure was used to remove outliers (if any existed) in the survey data since these evaluations were made using state level summary data from the Survey Processing System and the record level data were not available for detecting any outliers. The items considered in this study include:

Labor Items: Total Number of Hired, Self-Employed and Unpaid Workers

Crop Items: Planted Acreage for Corn, Soybean, Sorghum, and Winter Wheat as well as Harvested Acreage for Hay and Winter Wheat

Hog Items: Total Number of Hogs and Number of Sows Farrowed

For each item, the performance of the MF estimator and the ratio estimator was determined by comparing the estimates to the official statistics. The relative mean deviation (R-MD) from the official statistics and the relative root mean square deviation (R-RMSD) from the official statistics were used as performance criteria. These computations were made at the regional level for each agricultural item.

The performance of the MF survey estimator varies with respect to list coverage for different items. The R-RMSD of these estimators, including the ratio estimator, decreases with an increase in list coverage for the labor items. This happens only in those cases for crop and hog items that do not have a good list frame coverage. The estimates most affected by incompleteness of the list frame had sizable contributions to the total estimate from regions with list coverage below 80%.

The performance for the MF survey estimators is evaluated for the base and non-base survey periods and is found to be comparable. However, for some items the R-RMSD in the base period is higher than in the non-base period. Also, a comparison is made between the performance of the MF survey estimator and that of the ratio estimator in the non-base survey periods. Their performances are similar when the list coverage exceeds 85%; otherwise, the MF survey estimator has smaller R-RMSD than the ratio estimator.

NOTES AND REMARKS

1. The present study is limited in scope since it focuses on the investigation of the difference between NASS MF estimates and the official statistics as a function of list coverage for each of the agricultural items studied. It does not investigate the specific reasons or causes for the difference found.

2. No formal statistical tests are conducted to assess the difference observed due to correlation expected between regional quarterly estimates used in the study which would violate the basic assumptions of a standard t-test. Instead, a R-RMSD or R-MD value is considered significant if its magnitude is high, particularly 50 percent or more higher relative to those for other items or estimators.

3. Base period refers to the first period of a survey cycle in the year that the survey estimate is made. So it may not be an optimum case in terms of NOL sample data. The reason for this was to have some consistency across items. For labor items, the DE estimates are available in January, April, July and October; the base period is July. For hog items, the ADMW and RWMW estimates are available in March and December; the base period is December. For most crop items, the IMMW estimates are available in March and December. For Winter Wheat, the IMMW estimates are available for March and September. For purposes of this study, March is used as the the base period for crop items.

4. Evaluations are made by comparing the MF estimates and the ratio estimates with the official statistics at the regional level. The regions are different for different agricultural items. The present study utilizes the regions as currently used by NASS.

DEFINITIONS

ADMW Estimator - Multiple frame estimator used for estimating hog items by combining a revised **Ad**justed list estimator with a **M**odified **W**eight estimator for the NOL.

DE Estimator - **D**irect **E**xpansion Estimator.

IMMW Estimator - Multiple frame estimator used for estimating crop items by combining a **IM**puted weight estimator for the list with a **M**odified **W**eight estimator for the NOL.

MF Estimator - A *Multiple Frame Estimator* combines separate, independently computed estimates from a list frame and the NOL component of an area frame into an estimate of the total. The use of the expression "MF Estimators" in this report refers to the DE estimator for labor items, the IMMW estimator for crop items, and the ADMW and RWMW estimators for hog items.

MD - The *Mean Difference* between results of a NASS estimator and the official statistics.

NASS - National Agricultural Statistical Service

Official Statistics - Agricultural Statistical Board Final Estimates

RMSD - The *Root Mean Squared Deviation* from the results of a NASS estimator and the official statistics.

R-MD - The *Relative Mean Difference* (see Formula 1) between the results of a NASS estimator and the official statistics.

R-RMSD - The *Relative Root Mean Squared Deviation* (see Formula 2) of the results of a NASS estimator and the official statistics.

RWMW Estimator - Multiple frame estimator used for estimating hog items by combining a **R**e**W**eighted estimator for the list with a **M**odified **W**eight estimator for the NOL.

INTRODUCTION

The National Agricultural Statistics Service (NASS) has been investigating estimation approaches that would minimize (or completely eliminate) the use of area-frame samples in adjusting a survey estimate for incompleteness of the list frame. These investigations were initiated because of the relatively high survey cost and respondent burden associated with the area frame samples and also because of the poor precision of the resulting estimates for the area that is non-overlapping with the list frame (NOL).

Alternative approaches have been proposed and investigated previously as discussed in Chhikara, et al (1995), Rumburg, et al (1993) and Vogel (1990). Several alternative estimators were considered and compared to the currently employed direct expansion (DE) estimator for various labor items as detailed in Perry, et al (1997 and its supplement in 1998) and Spears, et al (1996, 1997). Overall, none of the alternative estimators consistently matched the performance of the DE. However, in some cases, alternative estimators performed comparably to the DE. The ratio estimator performed well in some cases and showed the most potential among the alternative estimators that rely less on the area frame than the DE. The performance to a large extent depended upon the size of the list frame coverage.

The present evaluation study is extended to crop and hog items for which NASS quarterly survey estimates and official statistics were available from June of 1993 to December of 1997. For the sake of comparison across various agricultural items, labor items are also included in the study. The performance of each multiple frame (MF) survey estimator is examined for both the base and non-base survey periods as well as the combined (all survey) periods. The ratio estimator is considered only for the non-base survey period, and its performance is evaluated for that period. The performance of a survey estimator is based on its value relative to the corresponding official statistics value. No algorithm or procedure could be used to remove outliers (if any existed) in the survey data due to the nature of the data utilized in this study.

The ratio estimate in a non-base survey period is obtained by multiplying the list estimate for that period by the ratio of total estimate to the list estimate as determined in the base survey period. The performance of the ratio estimator is examined as a function of the list frame coverage and compared to that of the MF survey estimator for various agricultural items.

NASS SURVEYS AND ESTIMATORS

The survey frequency and estimation methodology for NASS sample surveys varies for different agricultural items. The survey estimation is based on a multiple frame approach that combines separate, independently computed estimates from a list frame and the NOL component of an area frame into an estimate of the total. NASS currently utilizes direct expansion estimators for both the list and NOL components as described in Kott (1990).

The following items were included in the evaluation of NASS MF estimators.

Labor Items
Quarterly labor surveys are conducted in January, April, July and October to estimate various characteristics for hired, self-

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employed and unpaid workers. The items considered in this study include the total number of hired, self-employed and unpaid workers. July is used as the base survey period and the following October, January, and April are the non-base periods used to determine the ratio estimates. Each item's quarterly estimates are computed separately for the 17 farm labor regions and these are compared with the corresponding official statistics for their evaluation.

Crop Items

Quarterly crop and stock surveys are conducted to estimate acreage, yield and production for crop and stock items. In this study, only the crop acreage estimates are evaluated. To estimate crop acreage, NASS utilizes direct expansion estimates computed using the IMMW estimator which combines an imputed weight estimator for the list with a modified weight estimator for the NOL. The crop items considered in this study include (1) the planted acreage for corn, sorghum, soybean and winter wheat, and (2) the harvested acreage for hay and winter wheat. The IMMW estimates are available in March and December for the items other than for winter wheat planted and harvested, for which estimates are available in March and September. So in this study, March is the base survey period for all crop items and the following December is the non-base period for the ratio estimator of corn, sorghum, soybeans, and hay; and September is the non-base period for the ratio estimator of winter wheat planted and harvested. The crop regions are those currently used by NASS.

Hog Items

Quarterly hog surveys are conducted to estimate various hog items. NASS direct expansion estimates of hog items use the ADMW estimator which combines a revised adjusted list estimator with a modified weight estimator for the NOL. The RWMW estimator is also used for the hog items which employs a reweighted estimator for the list. The hog items considered in this study include the total number of hogs and the number of sows farrowed. The ADMW and RWMW estimates are available for these items in March and December. The estimates of the number of marketed hogs in various weight categories were also evaluated. December is the base period and the following March is the non-base period for the ratio estimator of hog items. The quarterly estimates are computed at the regional level; the hog regions are the same as those used by NASS.

Due to changes in the Hog Survey program, the March 1997 survey included only a list frame sample. The NOL component was modeled based on post-stratified December 1996 MF to list frame ratios. The March 1997 MF estimate was treated the same as the ADMW estimates from previous years in the R-RMSD and R-MD calculations

Ratio Estimator

A ratio estimate for a non-base survey period can be obtained using a multiple frame estimate from a base survey period. Both the list frame and the NOL must be estimated during a base survey period. For non-base survey periods, the list frame estimate is multiplied by the ratio of the multiple frame estimate (list + NOL) to the list frame estimate for the base survey period to obtain the ratio estimate. (A ratio estimate can be different from a multiple frame estimate only in a non-base period.) Hence it is evaluated only for the non-base periods.

Table 1: **Summary of Regional List Coverage (in percent) for Crops**

	Planted				Harvested	
	Corn	Soybean	Sorghum	Winter Wheat	Hay	Winter Wheat
Min	79.4	77.8	76.4	78.4	30.6	78.4
Mean	87.6	86.1	87.5	87.3	70.7	88.0
Max	93.2	94.6	96.6	95.0	92.9	95.0

Table 2: **Summary of Regional List Coverage (in percent) for Hogs and Workers**

	Hogs		Workers		
	Total	Sows Farrowed	Hired	Self-Employed	Unpaid
Min	69.8	59.0	72.6	38.1	38.7
Mean	90.2	89.9	81.7	52.0	61.0
Max	99.3	99.6	91.8	76.2	84.1

EMPIRICAL EVALUATIONS

The performance of the estimators described in the previous section is evaluated using operational estimates from the quarterly agricultural surveys from 1992-1997 for regions in the United States. For labor items, the study period is from June 1992 to April 1996, whereas for crop and hog items, it is from June 1993 to December 1997. The regional level estimates are compared to the official statistics which represent the final revised NASS Board estimates, and their performance is examined as a function of list frame coverage.

The list frame coverage is estimated by the ratio of the average list frame estimate to the average multiple frame estimate in the base survey period, obtained for the entire study period. The level of coverage of the list frame varies substantially at the state and regional level for some of the agricultural items. The list coverage for items other than self-employed workers, unpaid workers, hay harvested and sows farrowed is mostly

between 70% and 99% at the regional level. It ranges between 31% and 93% for harvested hays, between 38% and 76% for self-employed workers, between 39% and 84% for unpaid workers, and between 59% and 100% for sows farrowed. The range and mean percent list coverage for regions are summarized in Tables 1 and 2.

The performance criteria are the relative root mean squared deviation (R-RMSD) and the relative mean deviation (R-MD), both measured from the official statistics (OS). Letting $\hat{Y}_i$ and $\hat{Y}_{OS,i}$ represent the item estimates for the ith survey period corresponding to the MF estimator and the official statistics, respectively, the R-RMSD is given by

$$\text{R-RMSD}(\hat{Y}) = \frac{\sqrt{\frac{1}{n} \sum_{i=1}^{n} (\hat{Y}_i - \hat{Y}_{OS,i})^2}}{\frac{1}{n} \sum_{i=1}^{n} \hat{Y}_{OS,i}}, \quad (1)$$

and the relative mean deviation (R-MD) is given by

Table 3: Average R-MD

Item Estimated	NASS MF Estimate			Ratio
	All	Base	Non-base	
Labor				
Hired Workers	0.031	0.056	0.019	0.046
Self-Employed Workers	0.018	0.039	0.010	0.042
Unpaid Workers[†]	0.034	0.064	0.017	0.086
Crops				
Corn Planted	0.016	0.021	0.013	0.020
Soybean Planted	0.006	-0.028	0.019	0.022
Sorghum Planted	-0.063	-0.082	-0.057	-0.028
Winter Wheat Planted	-0.066	-0.062	-0.068	-0.064
Hay Harvested	0.008	-0.004	0.011	0.006
Winter Wheat Harvested	-0.025	0.013	-0.042	-0.042
Hogs				
Total Hogs	-0.057	-0.056	-0.057	-0.058
Sows Farrowed	-0.029	-0.042	-0.026	-0.026

[†] Results from the Mountain III Region were not included because of large discrepancies between the direct expansion estimates and the official statistics, possibly due to some outlier(s) in the record level data.

$$\text{R-MD}(\hat{Y}) = \frac{\frac{1}{n}\sum_{i=1}^{n}(\hat{Y}_i - \hat{Y}_{OS,i})}{\frac{1}{n}\sum_{i=1}^{n}\hat{Y}_{OS,i}}, \quad (2)$$

where n denotes the number of survey periods for which estimates are computed. For the MF estimators these quantities are computed at the regional level separately for the base and non-base survey periods as well as for all periods combined. Since the ratio estimates are only computed for the non-base periods, its R-RMSD and R-MD are obtained only for the non-base periods.

For each agricultural item, the average R-MD and average R-RMSD are computed across all regions by weighting the regions in terms of their list coverage. These results are summarized in Tables 3 and 4, respectively.

Appendix A contains (in Figures A1-A11) bubble plots of the R-RMSD for each region versus the list coverage for that region for each of the items evaluated in this study. The size of each bubble is proportional to the size of the contribution of the estimate from that region to the national estimate. For each item, the R-RMSD is plotted for the MF estimator using (1) all survey periods, (2) base survey periods, and (3) the non-base survey periods; and for the ratio estimator using non-base survey periods. Similar plots for the R-MD are included in Appendix B.

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Table 4: **Average R-RMSD**

Item Estimated	NASS MF Estimate			Ratio
	All	Base	Non-base	
Labor				
Hired Workers	0.084	0.084	0.079	0.118
Self-Employed Workers	0.054	0.065	0.0463	0.100
Unpaid Workers†	0.098	0.103	0.075	0.212
Crops				
Corn Planted	0.054	0.057	0.050	0.057
Soybean Planted	0.061	0.061	0.058	0.067
Sorghum Planted	0.150	0.183	0.123	0.117
Winter Wheat Planted	0.091	0.087	0.091	0.088
Hay Harvested	0.104	0.117	0.095	0.116
Winter Wheat Harvested	0.090	0.104	0.076	0.076
Hogs				
Total Hogs	0.059	0.065	0.055	0.065
Sows Farrowed	0.070	0.064	0.071	0.079

† Results from the Mountain III Region were not included because of large discrepancies between the direct expansion estimates and the official statistics, possibly due to some outlier(s) in the record level data.

Labor Items

The average R-MD is positive for all labor items at the regional level. The R-MD is higher on average for the ratio estimator than for the DE estimator for the non-base period. However, in all cases, the bias reflected by the positive R-MD is small and statistically insignificant.

Figures A1-A3 show that the R-RMSD decreases as list coverage increases for the DE and ratio estimators. The decrease is substantially more for the ratio estimator.

Since the R-RMSD for the non-base period is smaller for the DE than for the ratio estimator, the DE has better performance than the ratio estimator.

Crop Items

For planted acreage, the R-MD is on average negative for the IMMW estimator for sorghum, soybean (base period) and winter wheat. However, these are statistically insignificant for every item. Figures in Appendix A for the crops show that the R-RMSD decreases as list coverage increases for corn and soybean, but fairly random in other cases. The average R-RMSD values given in Table 4 show that the performance is similar in the base and non-base periods for the IMMW direct expansion estimator. Also, the direct expansion and ratio estimator have comparable performance.

For harvested acreage, the R-MD is on average negative, yet statistically insignificant, for the IMMW estimator for winter

Figure 1: Ratio of Mean R−RMSD versus Mean List Coverage
Ratio Versus NASS Estimator (Non-Base Period)

Item Estimated			
○ ○ ○ Hired	□ □ □ Self	△ △ △ Unpd
* * * CrnPl	◇ ◇ ◇ HayHv	+ + + SoyPl
♯ ♯ ♯ SrgPl	● ● ● WWhHv	× × × WWhPl
☆ ☆ ☆ Sows	⊕ ⊕ ⊕ Hogs	
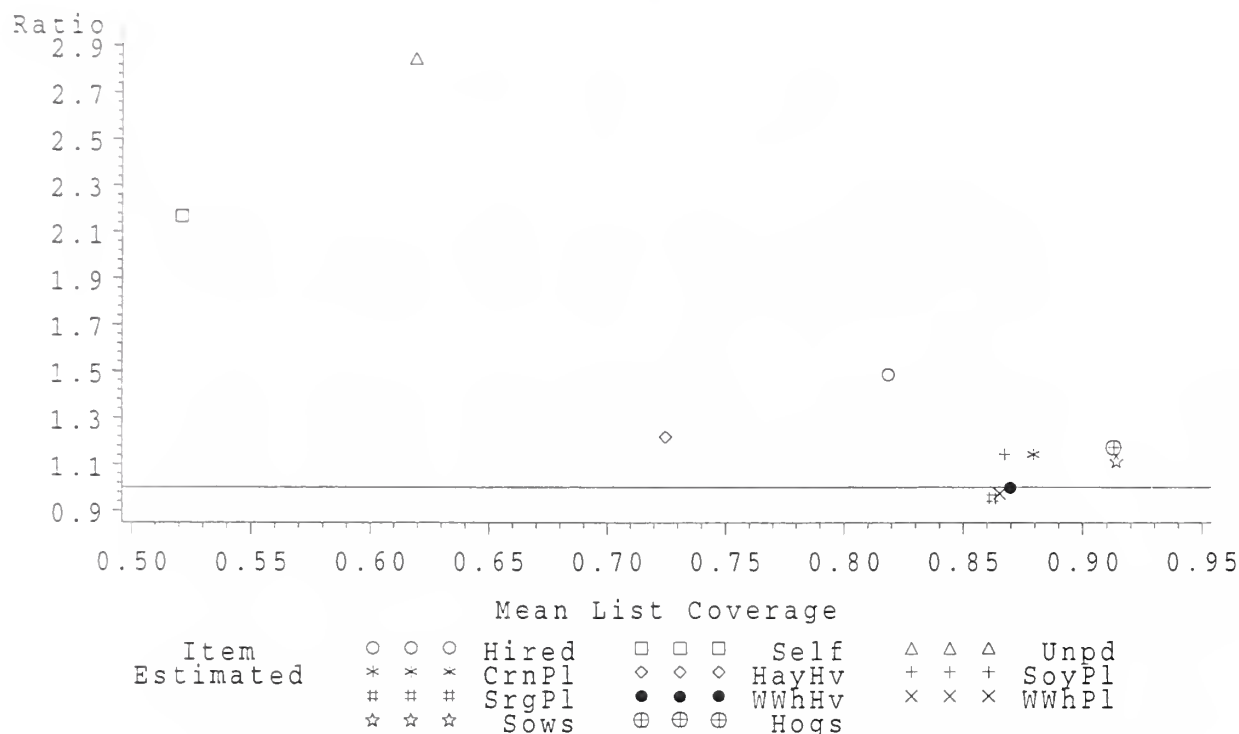
wheat. The average R-MD for hay is almost equal to zero. There is no decrease in R-RMSD as list coverage increases for harvested acreage of any of the items. The performances of the IMMW direct expansion and ratio estimators are again comparable.

Hog Items

The R-MD is on average negative for the ADMW estimator, although statistically insignificant, and R-RMSD decreases slightly as list coverage increases for the total hogs and the number of sows farrowed. Similar results are obtained, though not included here, for the RWMW estimator. The performance of the ADMW (or RWMW) is similar in the base and non-base periods, and the ratio estimator performs similarly, as well. These

conclusions follow from Tables 3 and 4, and Figures A4 and A5 given in Appendix A.

Evaluations of the MF survey estimates for market hogs in various weight categories were also made. The performance of the individual weight category estimates was found to be somewhat inconsistent, so it is not reported here.

CONCLUSIONS

A number of conclusions follow as a result of this study of the performance of the MF survey and ratio estimators for various agricultural items.

- The ratio estimator has R-RMSD within 20% of that of the MF estimators for all items other than the la-

Figure 2: Ratio of Mean R−RMSD versus Mean List Coverage
NASS Estimator (Base versus Non-Base Periods)
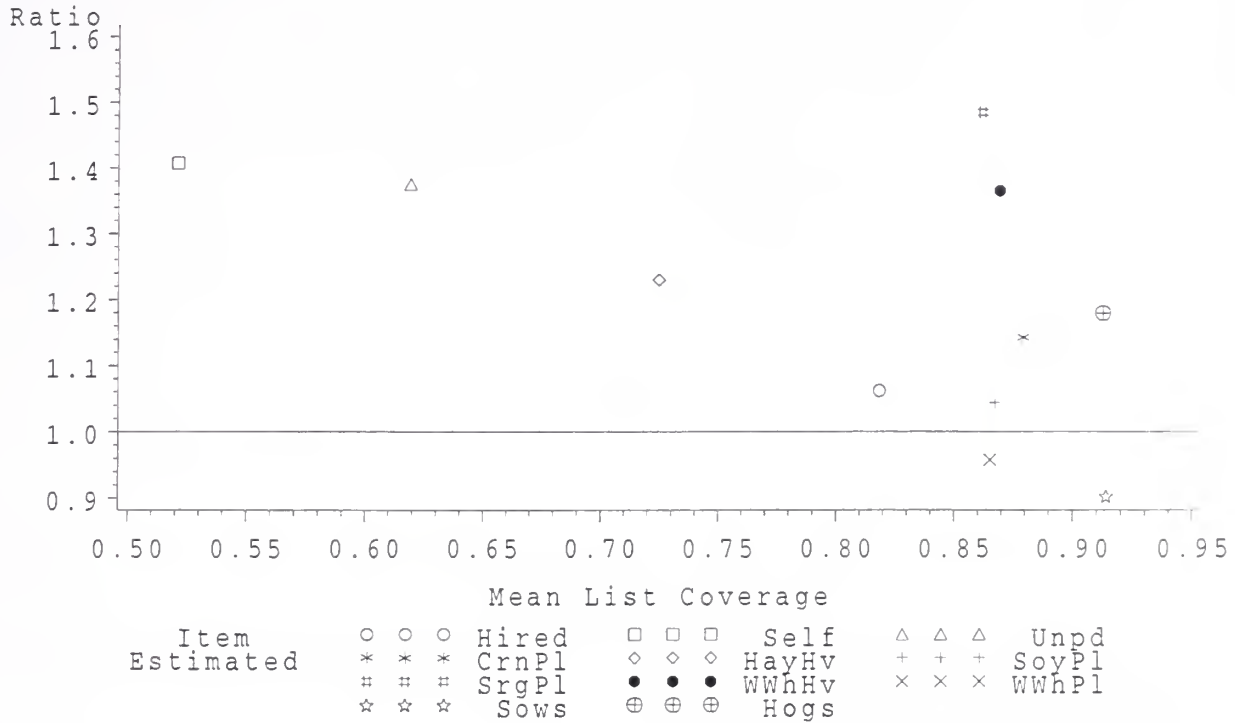
bor items. When the list coverage exceeds 85%, the ratio estimator has performance comparable to the MF estimators. These results can be seen in Figure 1. It shows the ratio of the mean R-RMSD for the ratio estimator to that of the MF survey estimator as a function of the mean list coverage for each of the items included in this study. The mean is obtained as a weighted average across all regions in each case.

Remark: The abbreviations for the items used in the legend are: "Hired" for number of hired workers, "Self" for number of self-employed workers, "Unpd" for number of unpaid workers, "CrnPl" for corn planted acreage, "HayHv" for hay harvested acreage,

"SoyPl" for soybean planted acreage, "SrgPl" for sorghum planted acreage, "WWhHV" for winter wheat harvested acreage, "WWhPl" for winter wheat planted acreage, "Sows" for number of sows farrowed and "Hogs" for total number of hogs.

- The MF estimators are comparable (within 20 percent) in their R-RMSD for base and non-base periods in all cases except self-employed and unpaid workers, sorghum planted acreage and harvested acreage for hay and winter wheat. In these cases, the R-RMSD in the base period is higher by 20 to 50 percent. See Figure 2 which plots the ratio of the mean R-RMSD in the base period to that of the non-base period in a manner similar to Figure 1.

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- The R-RMSD of the MF estimator decreases with increased list coverage for all labor items and soybean planted acreage. In most other cases, a decrease in R-RMSD as a function of list coverage is seen with respect to regions that are substantially contributing to the total estimate for an item.

- The average R-MD of the ratio estimator is comparable to that of the MF estimator for all items other than the labor items.

- The average R-MD of the MF estimators are comparable for base and nonbase periods in all cases except labor items. It is higher by a multiple of almost 3 or more in the base period for the labor items.

- The R-MD is negative for most regions of planted acreage of sorgum and winter wheat, and it is positive for all labor items.

Overall, the performance of the MF survey estimator varies with respect to the list coverage for different items. The estimates most affected by incompleteness of the list frame have sizeable contributions from regions with list coverage below 80% which can be seen from the Figures in Appendix A; for example, in the cases of hay harvested acreage and unpaid workers, major contributions to their estimates come from regions having list coverage of less than 80%.

The ratio and MF survey estimators have similar performance in cases where the list coverage exceeds 85%.

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APPENDIX A: REGIONAL LEVEL R-RMSD RESULTS

List of Figures   .

Using the Quarterly Agricultural Surveys from states or agricultural regions in the United States, estimates of various labor items from 1992-96 and various hog and crop items from 1993-97 were compared to the official statistics at the regional level using the relative root mean squared deviation (R-RMSD) as the performance criterion.

Figure A1: R-RMSD versus List Coverage
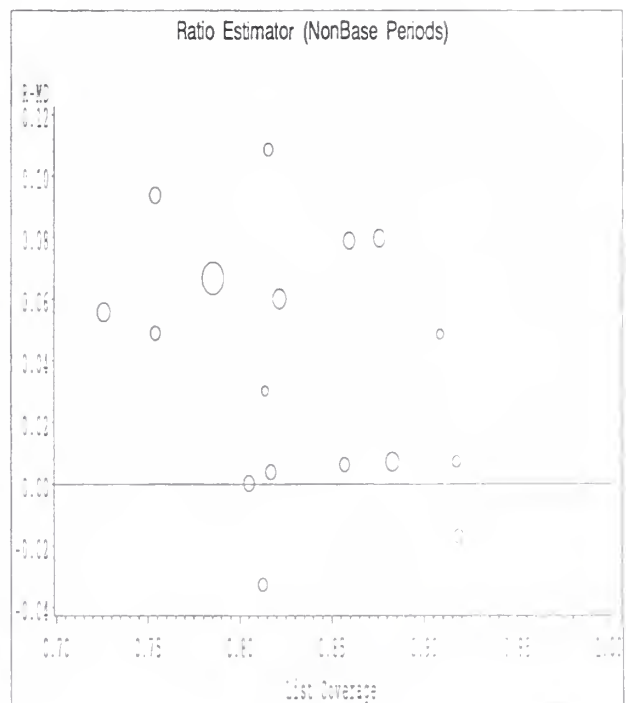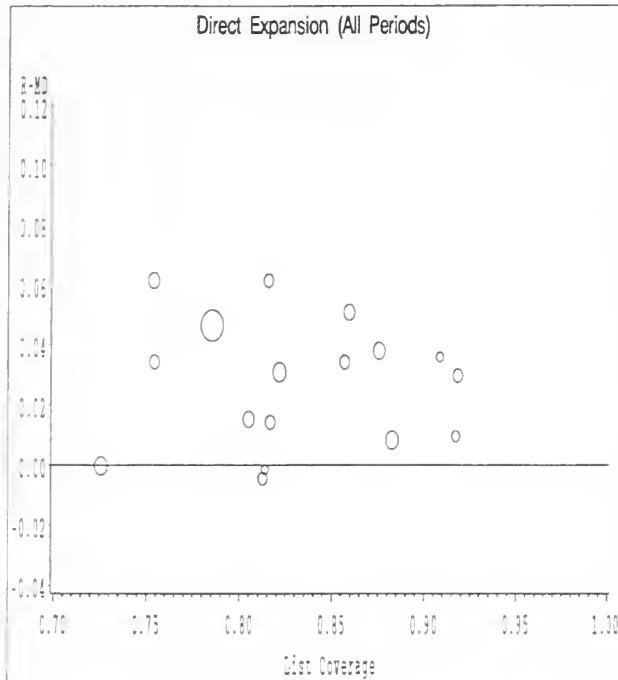## Total Hired Workers (Region)
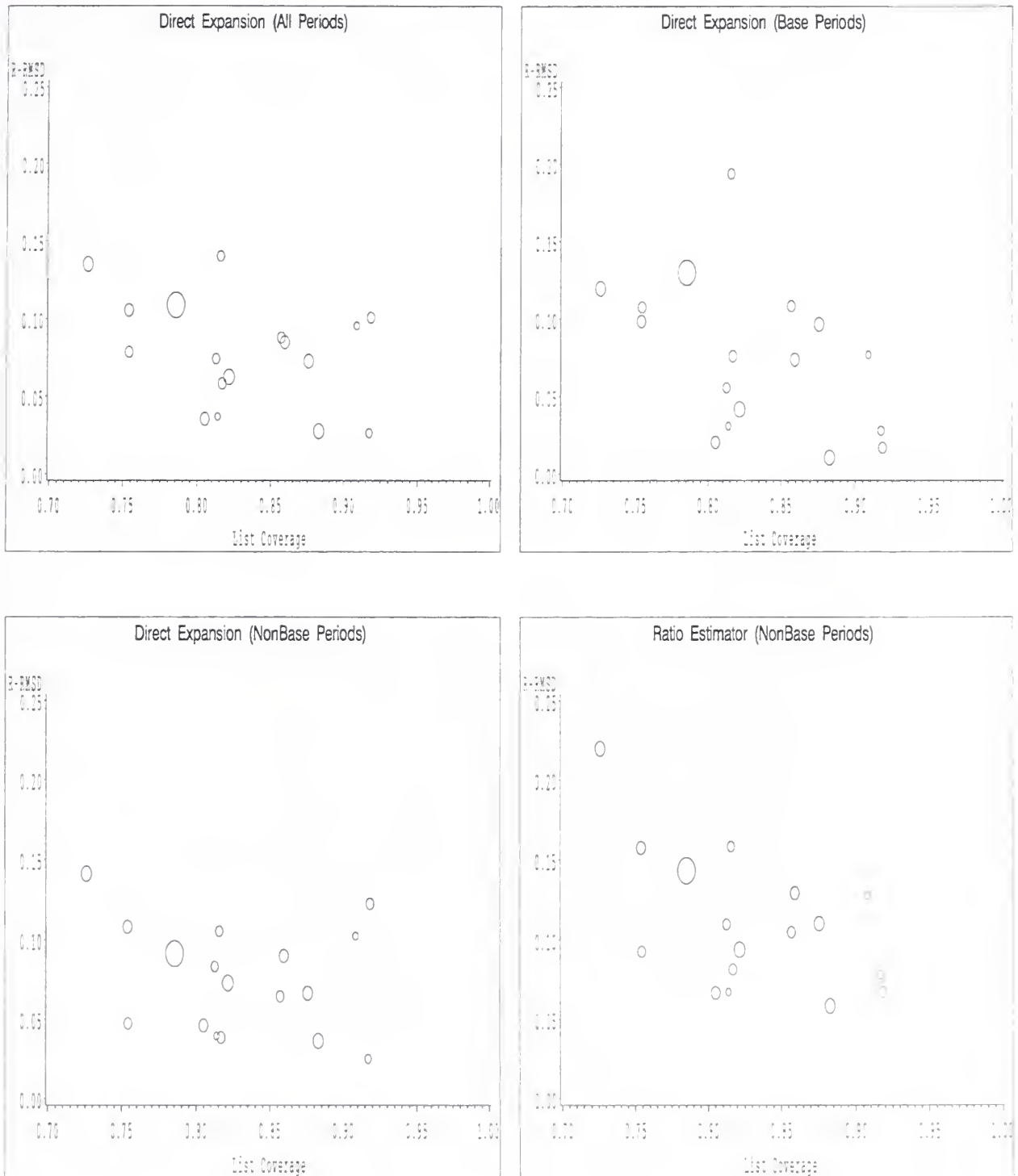
Figure A2: R−RMSD versus List Coverage
Total Self−Employed Workers (Region)

Direct Expansion (All Periods)

Direct Expansion (Base Periods)

Direct Expansion (NonBase Periods)

Ratio Estimator (NonBase Periods)
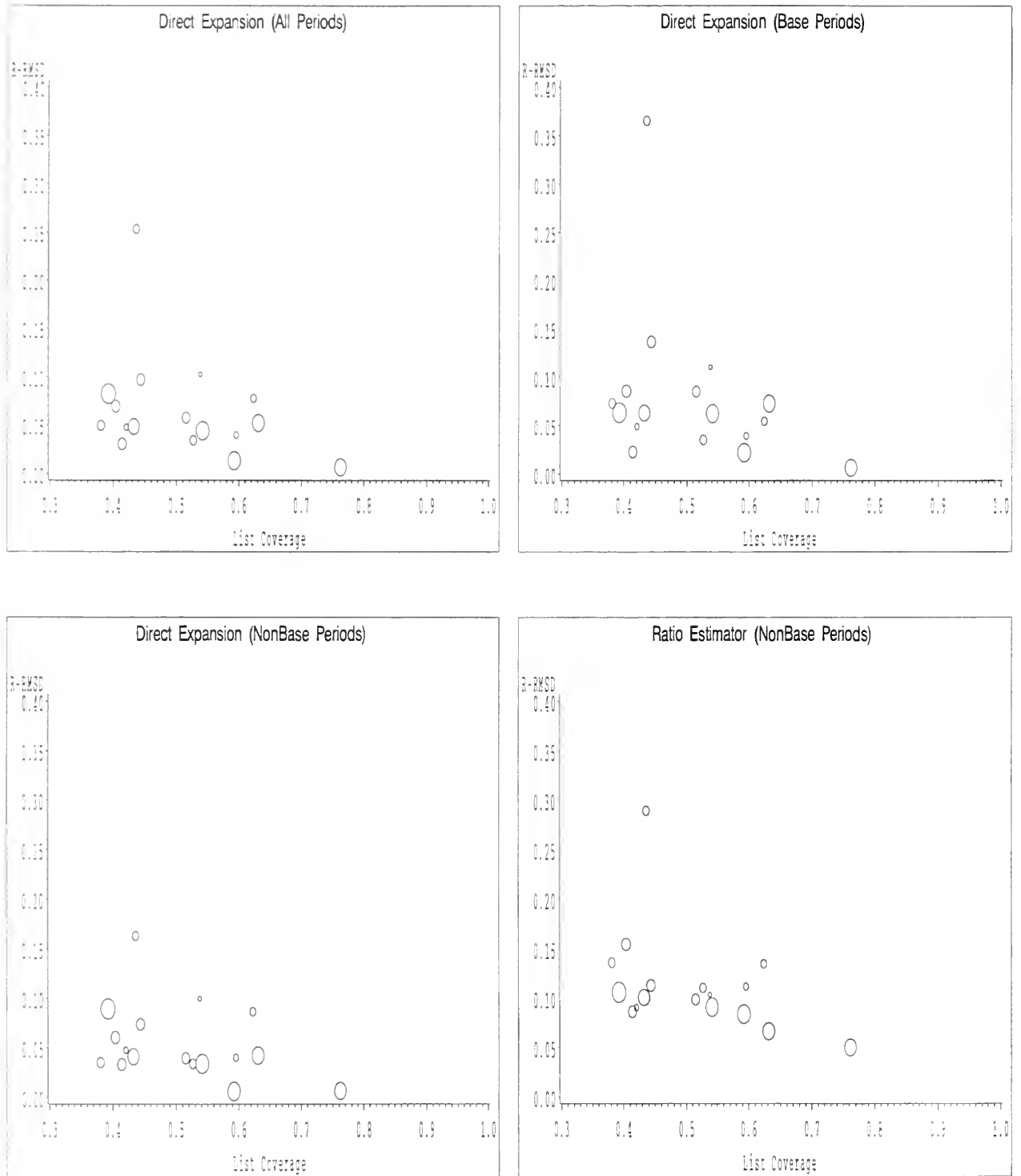
Figure A3: R−RMSD versus List Coverage
Total Unpaid Workers (Region)

Direct Expansion (All Periods)

Direct Expansion (Base Periods)

Direct Expansion (NonBase Periods)

Ratio Estimator (NonBase Periods)

13
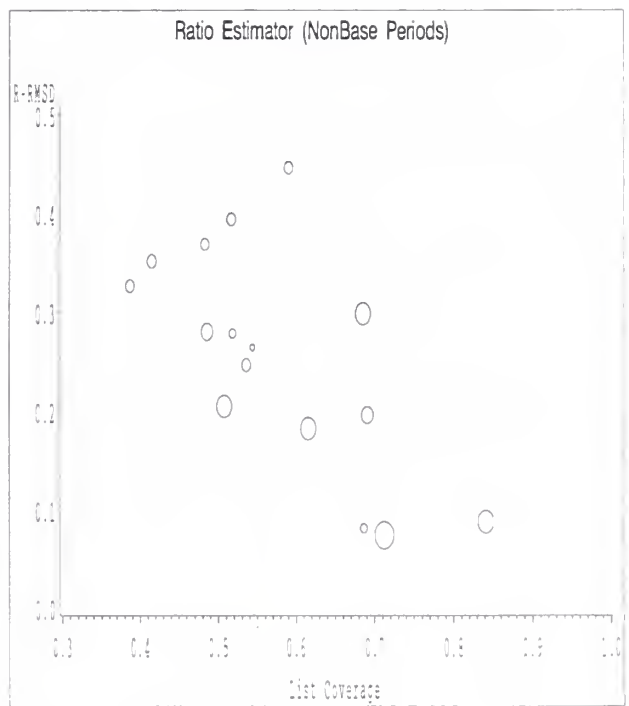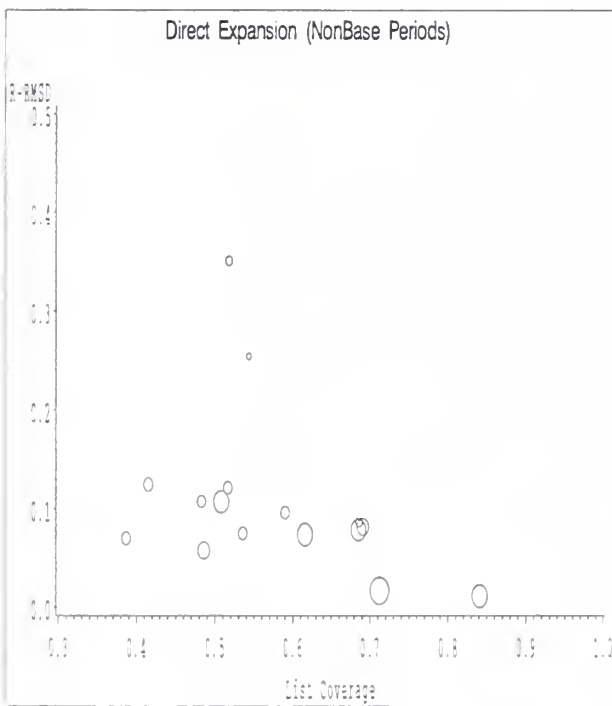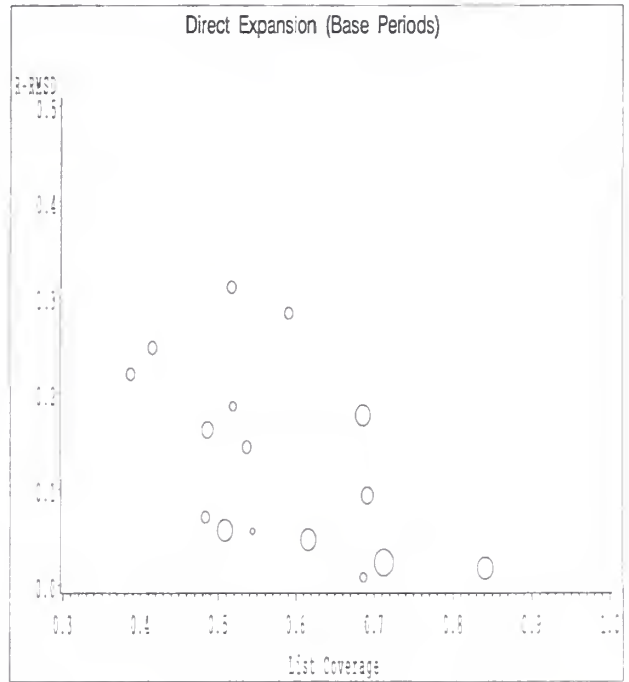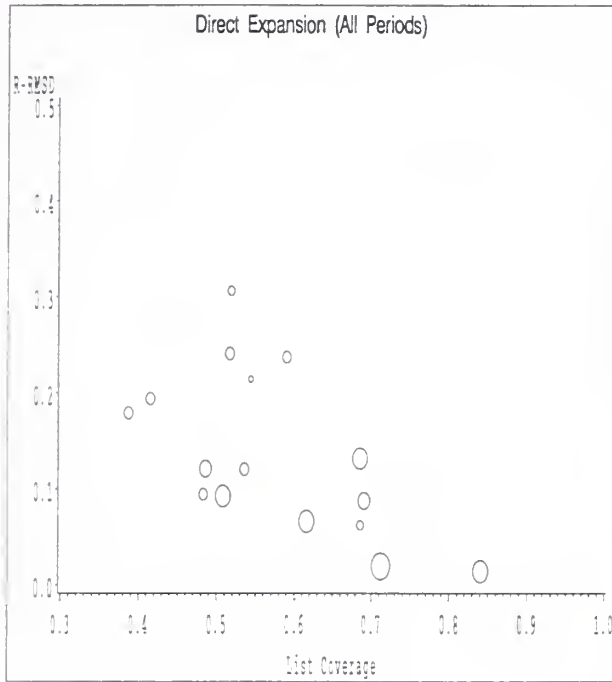
Figure A4: R–RMSD versus List Coverage
Total Hogs (Region)

Rev Adj List + Mod Wt NOL (All Periods)

Rev Adj List + Mod Wt NOL (Base Periods)

Rev Adj List + Mod Wt NOL (NonBase Periods)

Ratio Estimator (NonBase Periods)

14
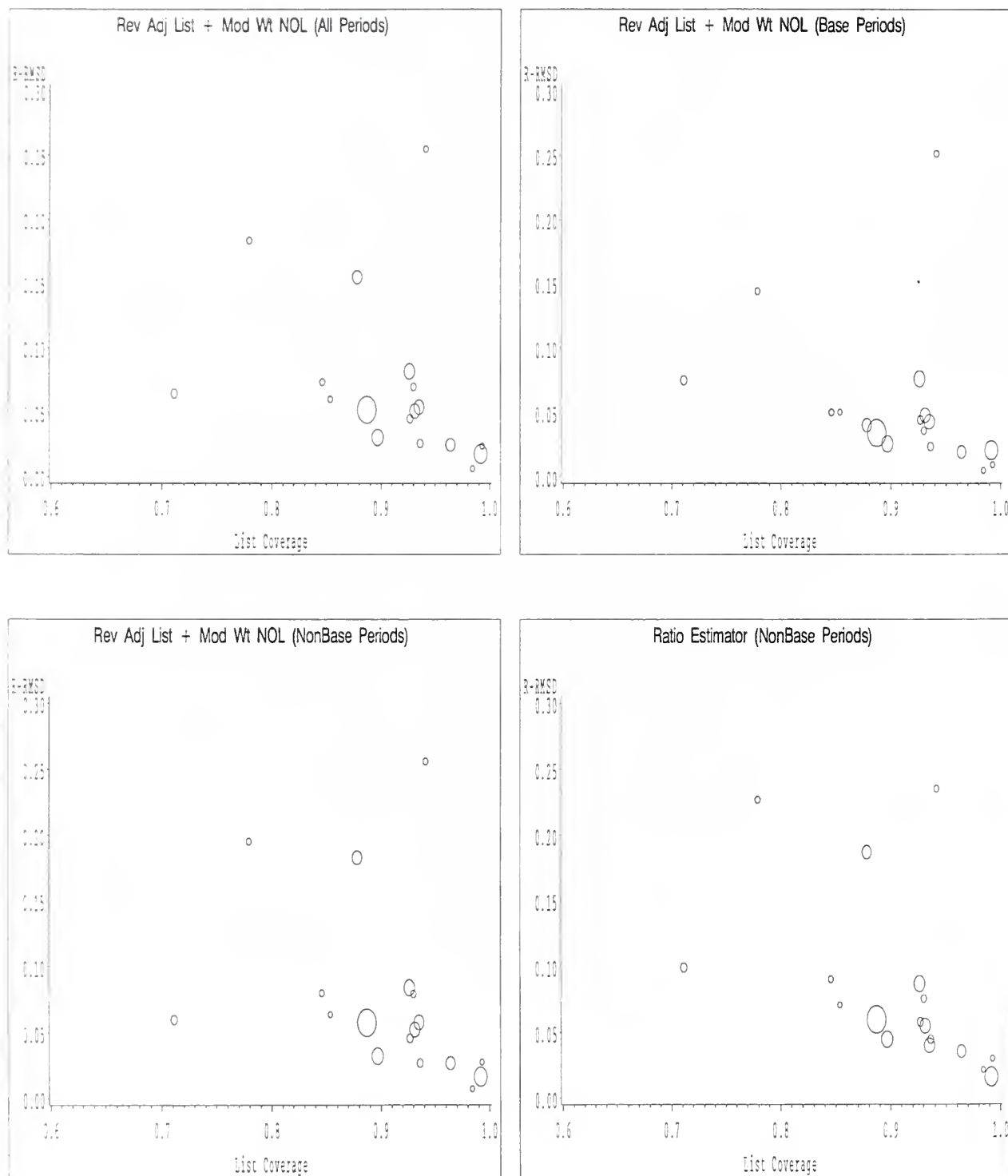
Figure A5: R–RMSD versus List Coverage
Sows Farrowed: Mar–May (Region)

Rev Adj List + Mod Wt NOL (All Periods)

Rev Adj List + Mod Wt NOL (Base Periods)

Rev Adj List + Mod Wt NOL (NonBase Periods)

Ratio Estimator (NonBase Periods)
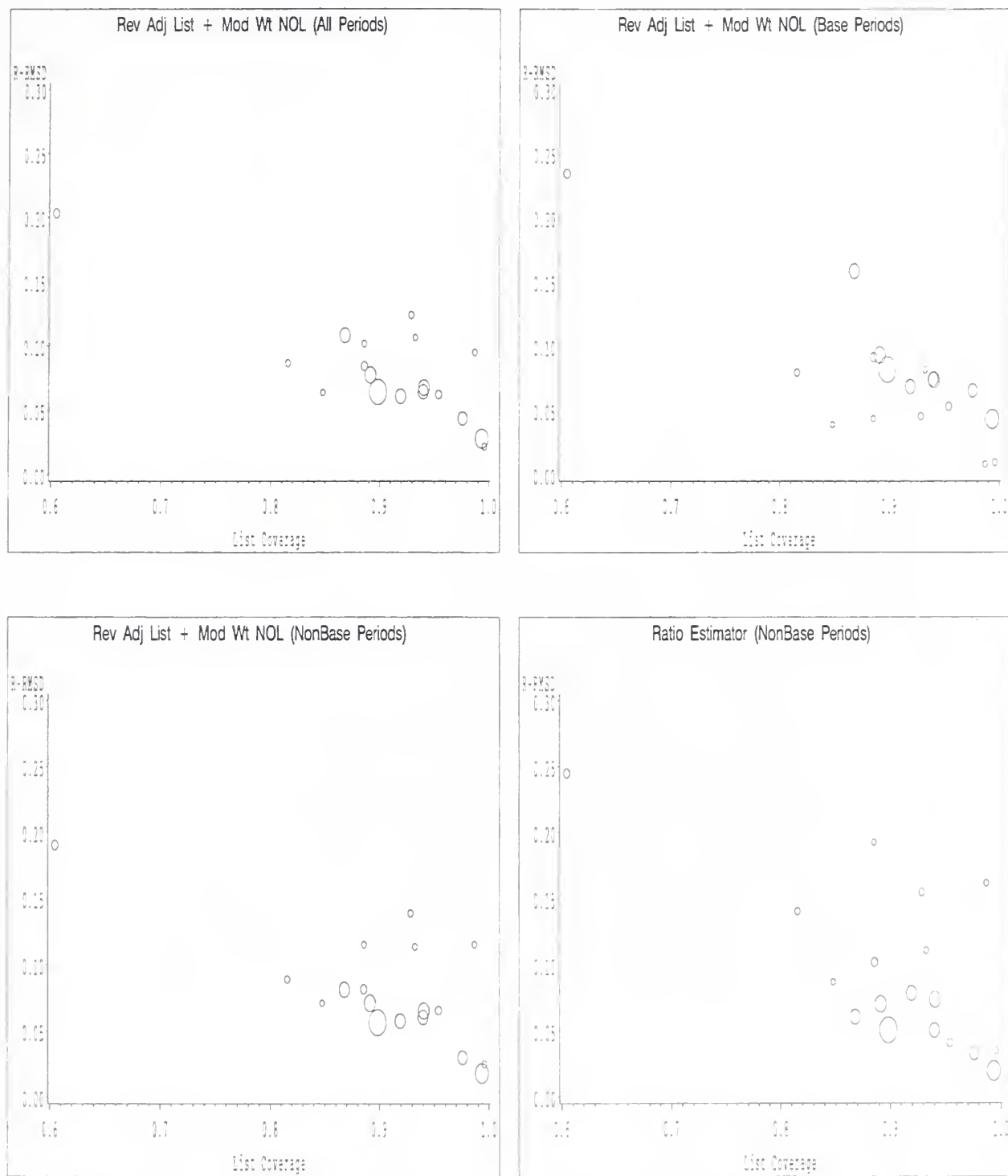
Figure A6: R–RMSD versus List Coverage

Corn – All Planted Acreage (Region)

Imp List + Mod Wt NOL (All Periods)

Imp List + Mod Wt NOL (Base Periods)

Imp List + Mod Wt NOL (NonBase Periods)

Ratio Estimator (NonBase Periods)

16
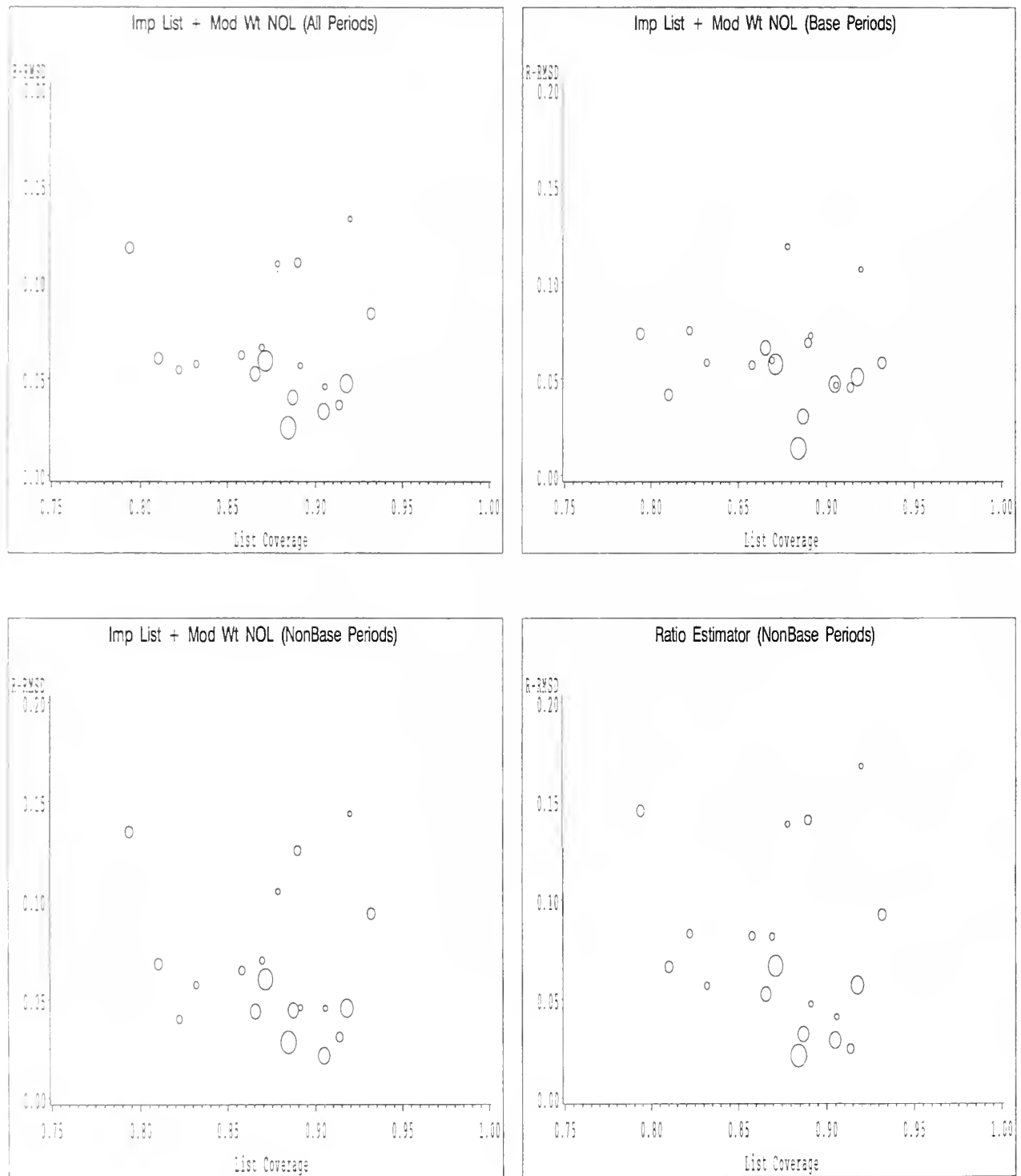
Figure A7: R−RMSD versus List Coverage
Hay − All Harvested Acreage (Region)

Imp List + Mod Wt NOL (All Periods)

Imp List + Mod Wt NOL (Base Periods)

Imp List + Mod Wt NOL (NonBase Periods)

Ratio Estimator (NonBase Periods)
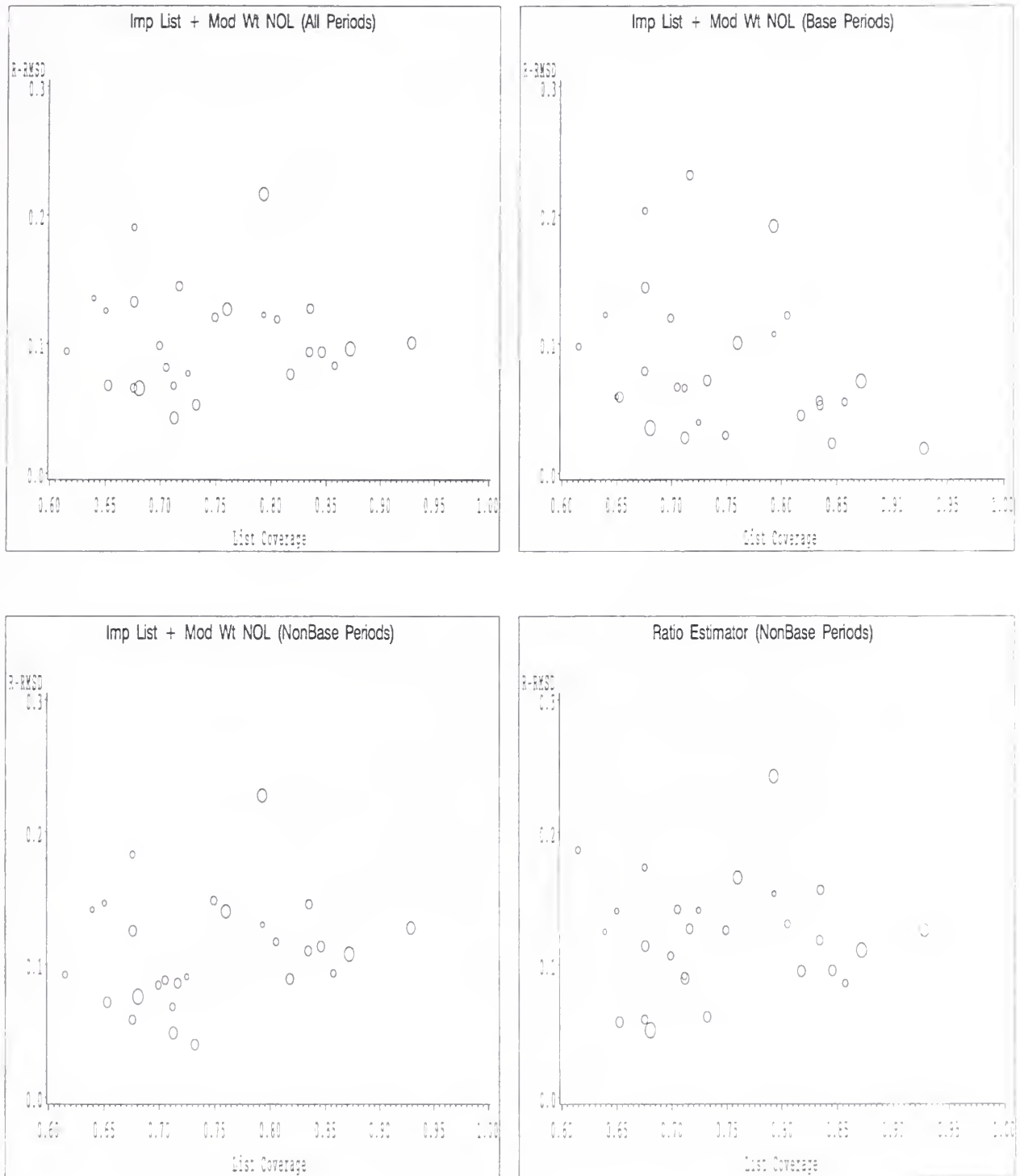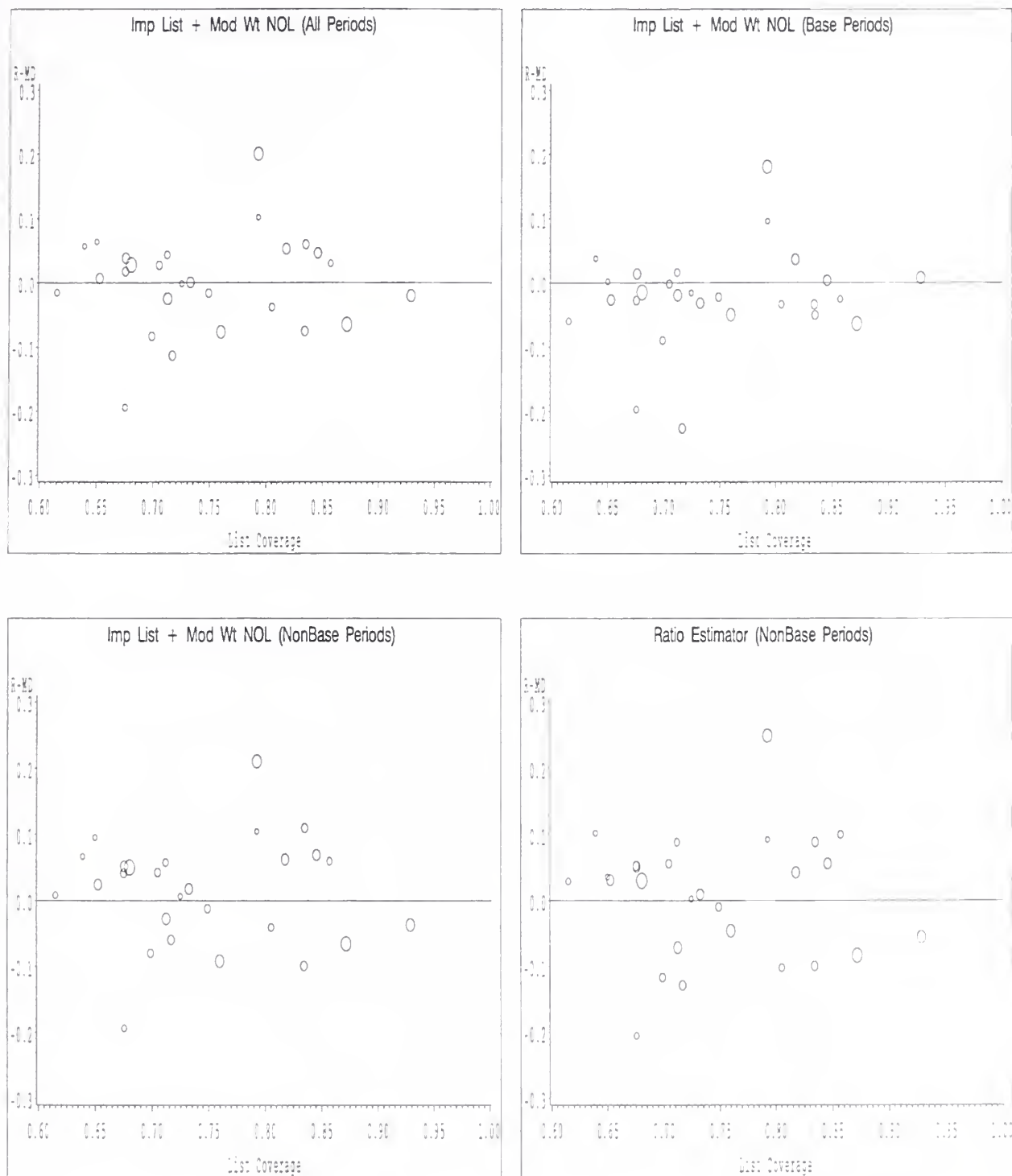
Figure A8: R–RMSD versus List Coverage
Soybean – All Planted Acreage (Region)
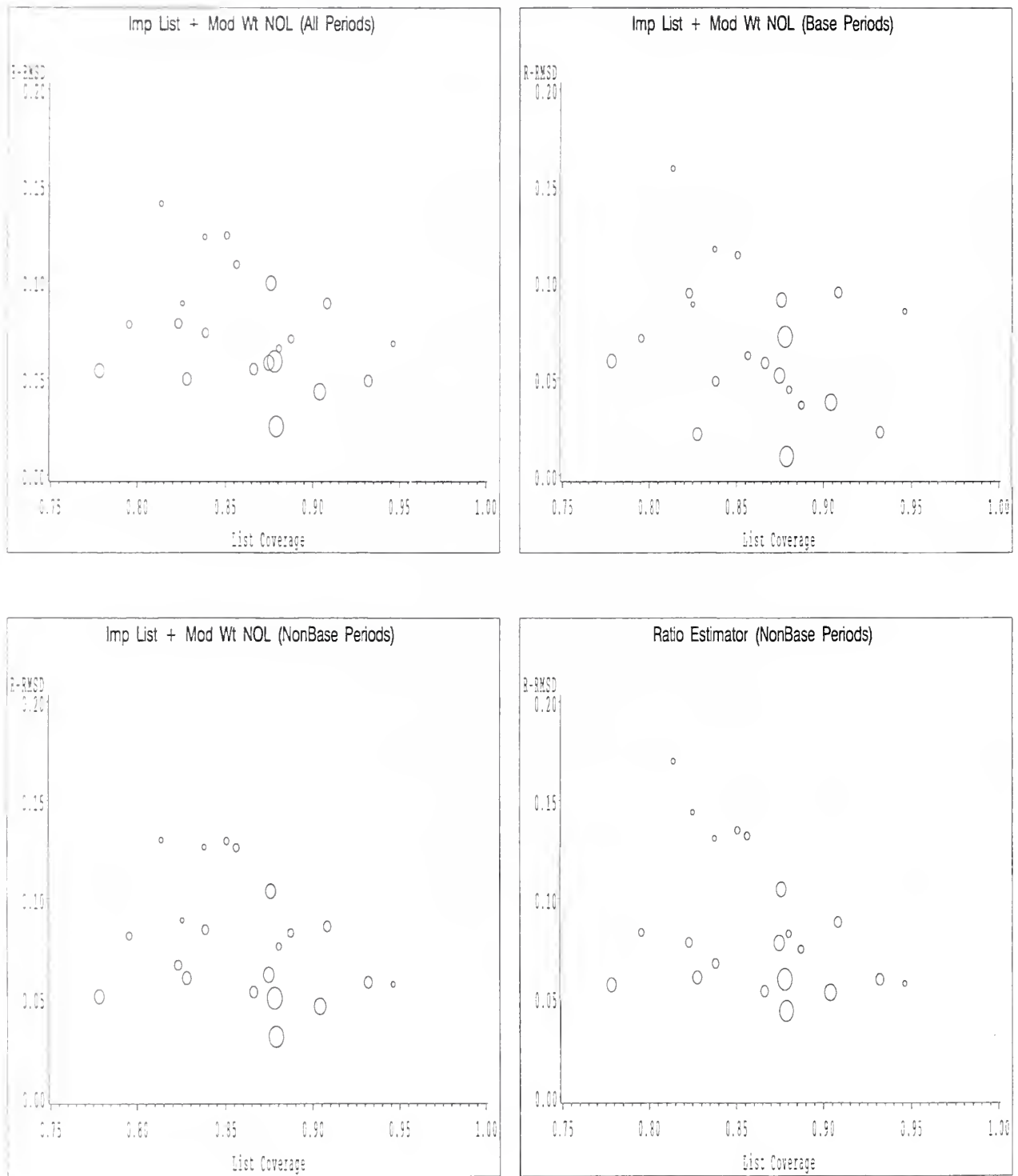
Figure A9: R–RMSD versus List Coverage
Sorghum – All Planted Acreage (Region)
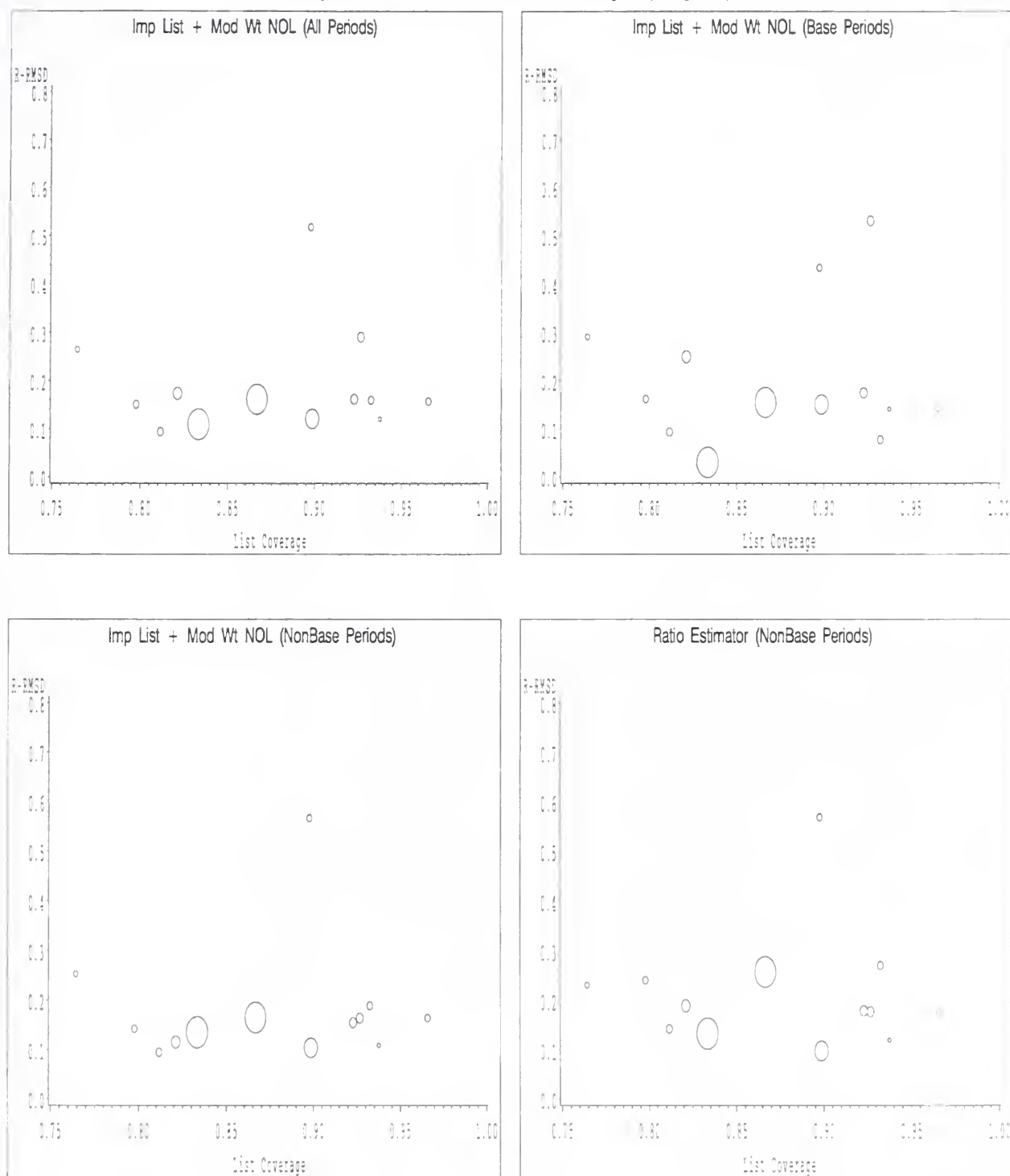
Figure A10: R−RMSD versus List Coverage
Winter Wheat − All Planted Acreage (Region)

Imp List + Mod Wt NOL (All Periods)

Imp List + Mod Wt NOL (Base Periods)

Imp List + Mod Wt NOL (NonBase Periods)

Ratio Estimator (NonBase Periods)
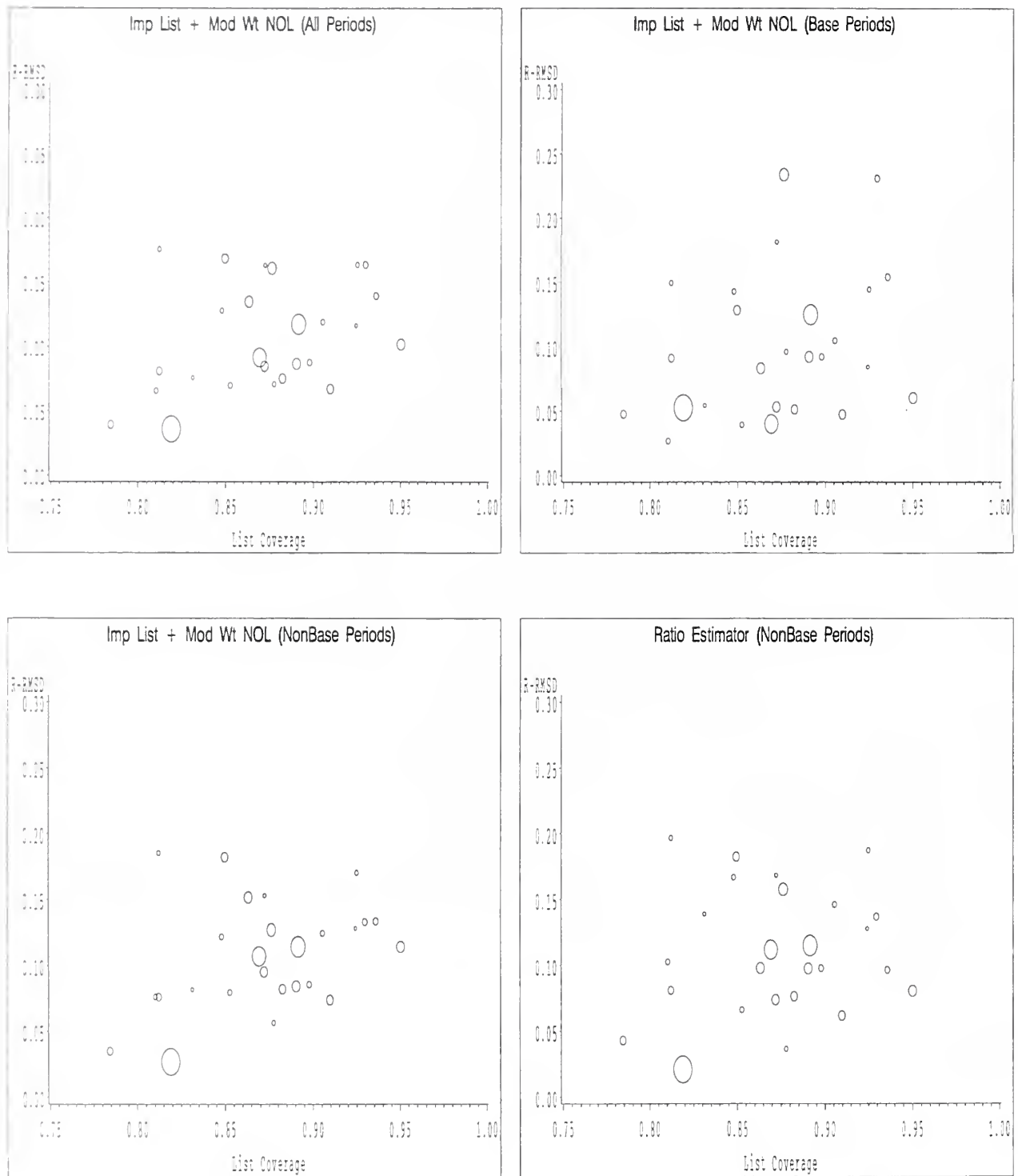
Figure A11: R–RMSD versus List Coverage
Winter Wheat – All Harvested Acreage (Region)
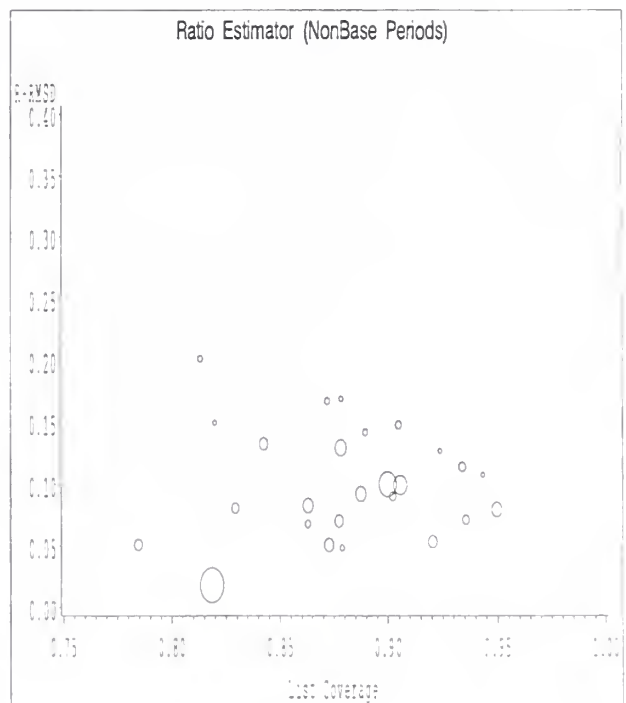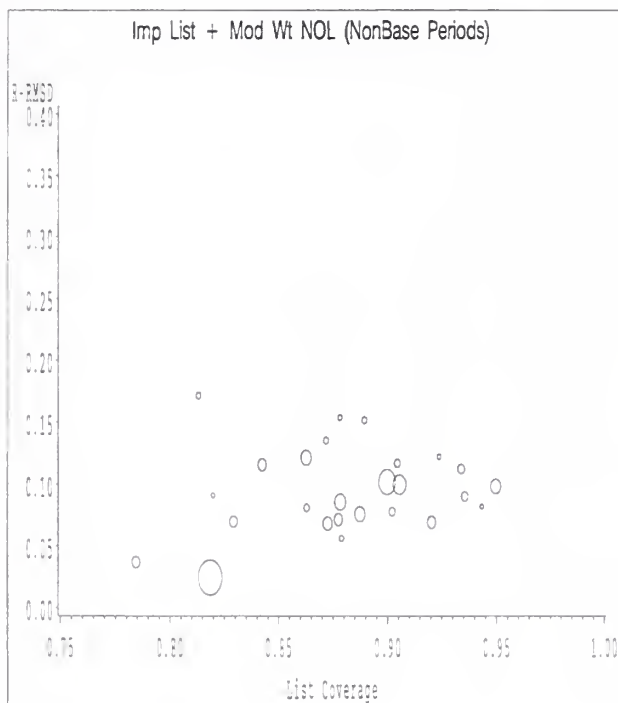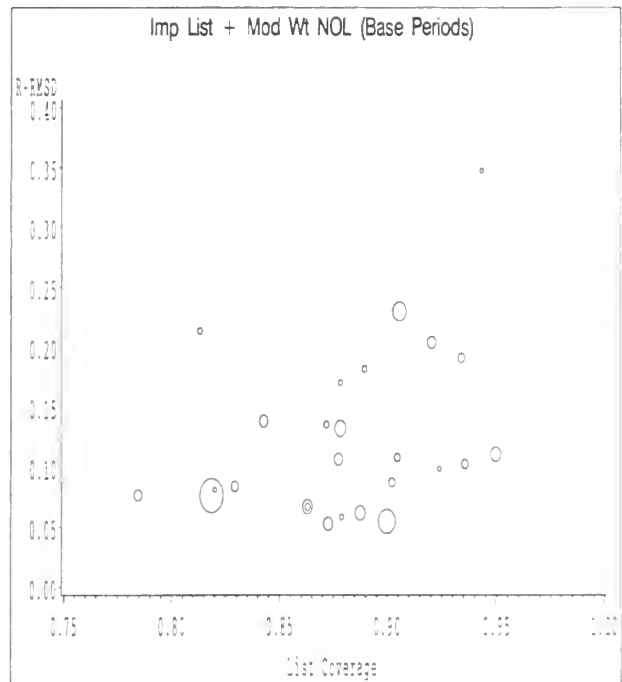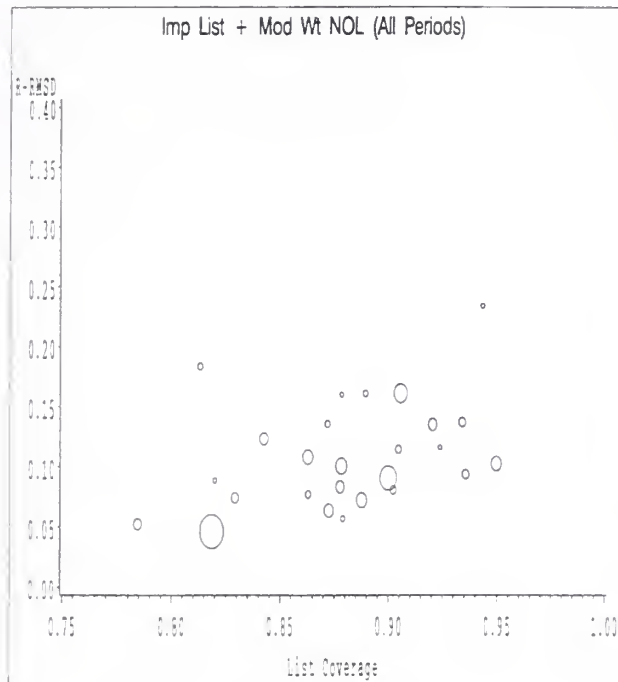
APPENDIX B: REGIONAL LEVEL R-MD RESULTS

List of Figures

Using the Quarterly Agricultural Surveys from states or agricultural regions in the United States, estimates of various labor items from 1992-96 and various hog and crop items from 1993-97 were compared to the official statistics at regional level using the relative mean deviation (R-MD) as the performance criterion.

Figure B1: R-MD versus List Coverage
Total Hired Workers (Region)
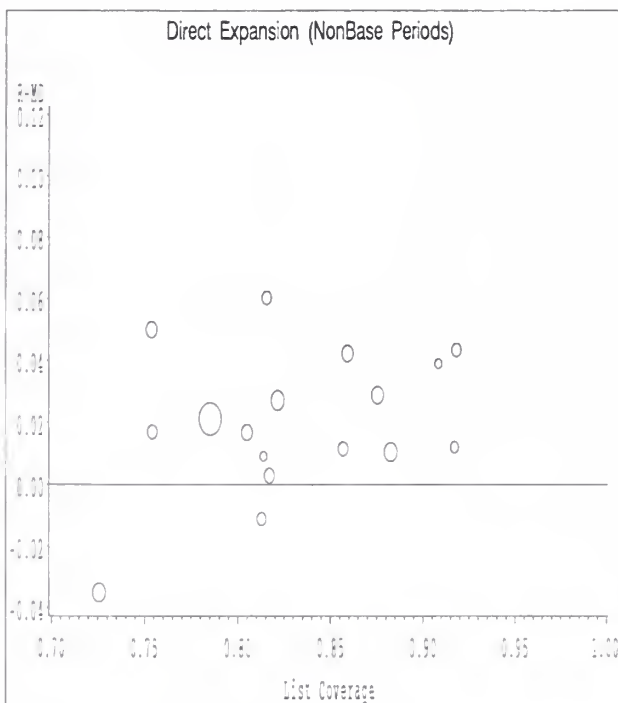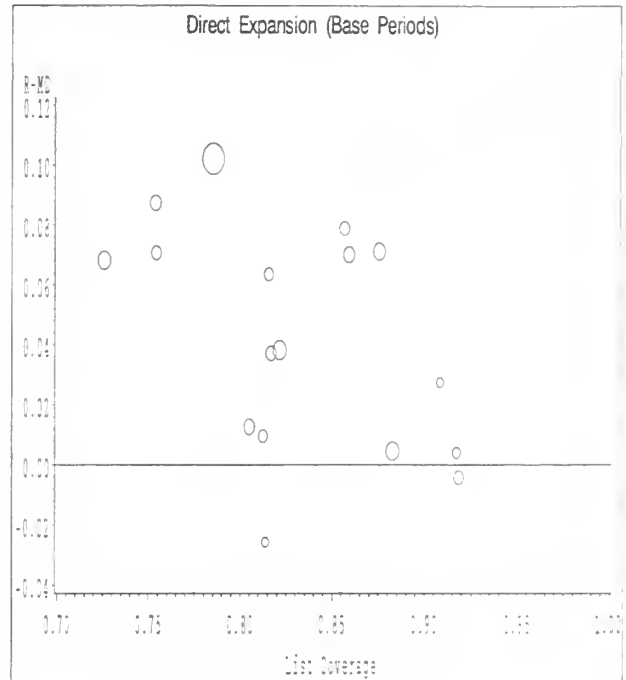
Figure B2: R-MD versus List Coverage
Total Self-Employed Workers (Region)
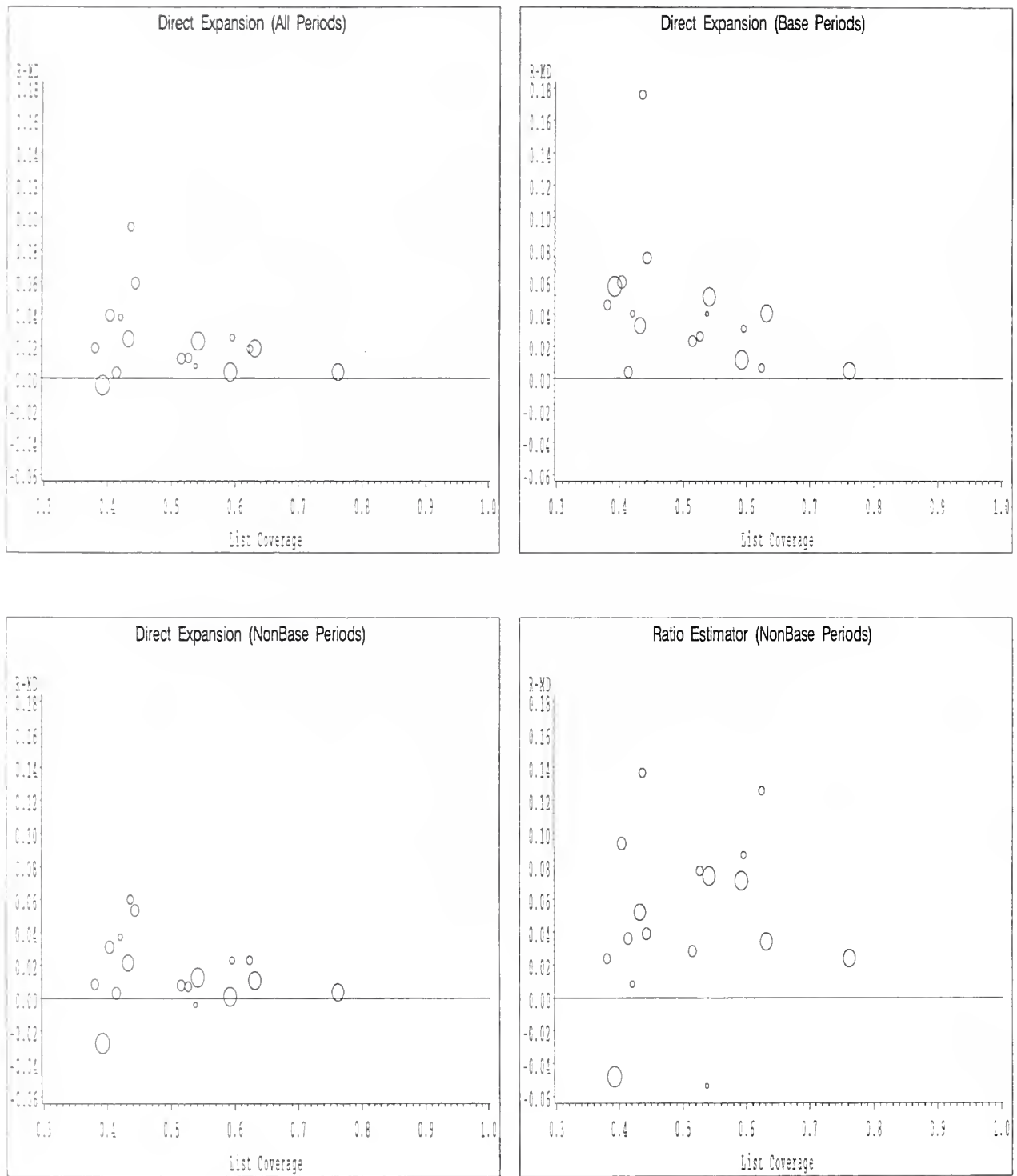
Figure B3: R–MD versus List Coverage
Total Unpaid Workers (Region)
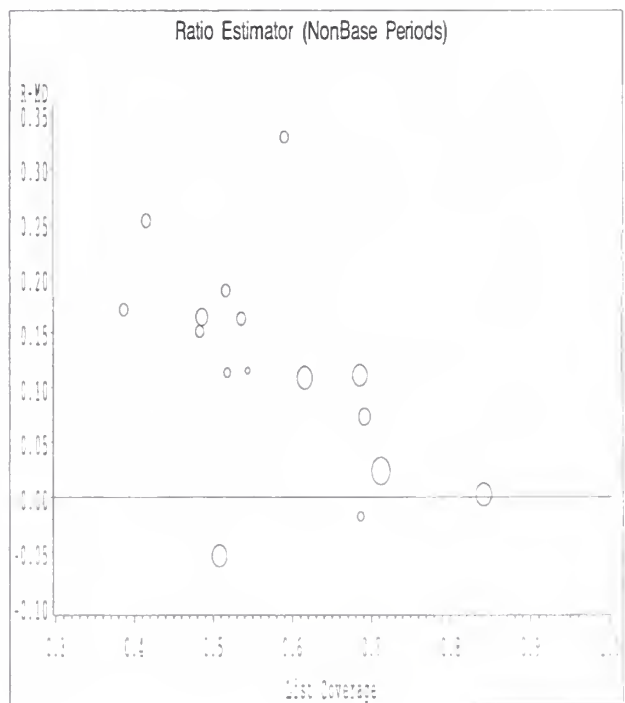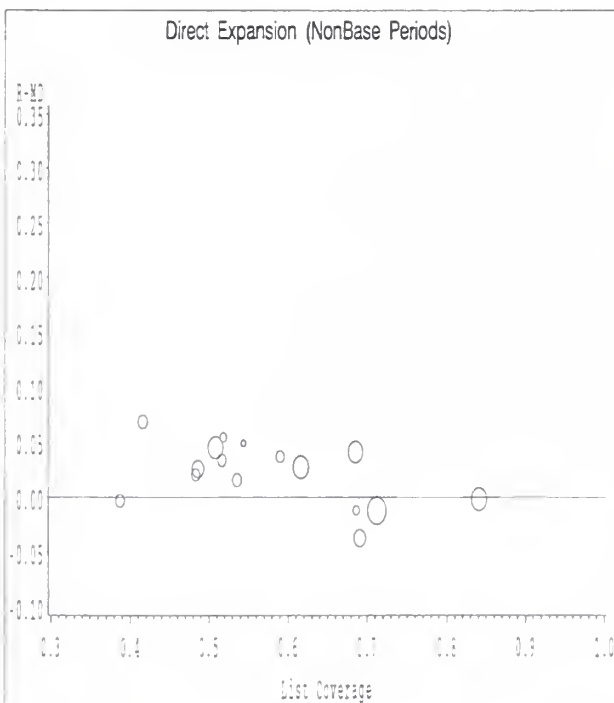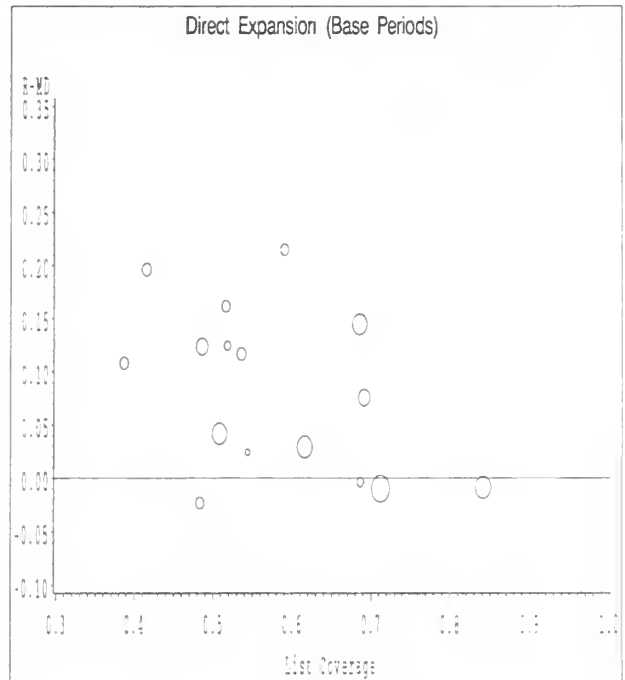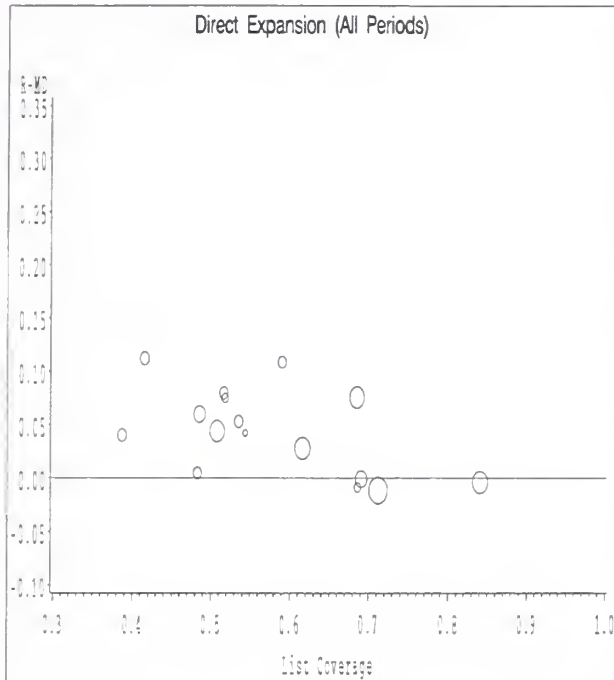
Figure B4: R-MD versus List Coverage
Total Hogs (Region)
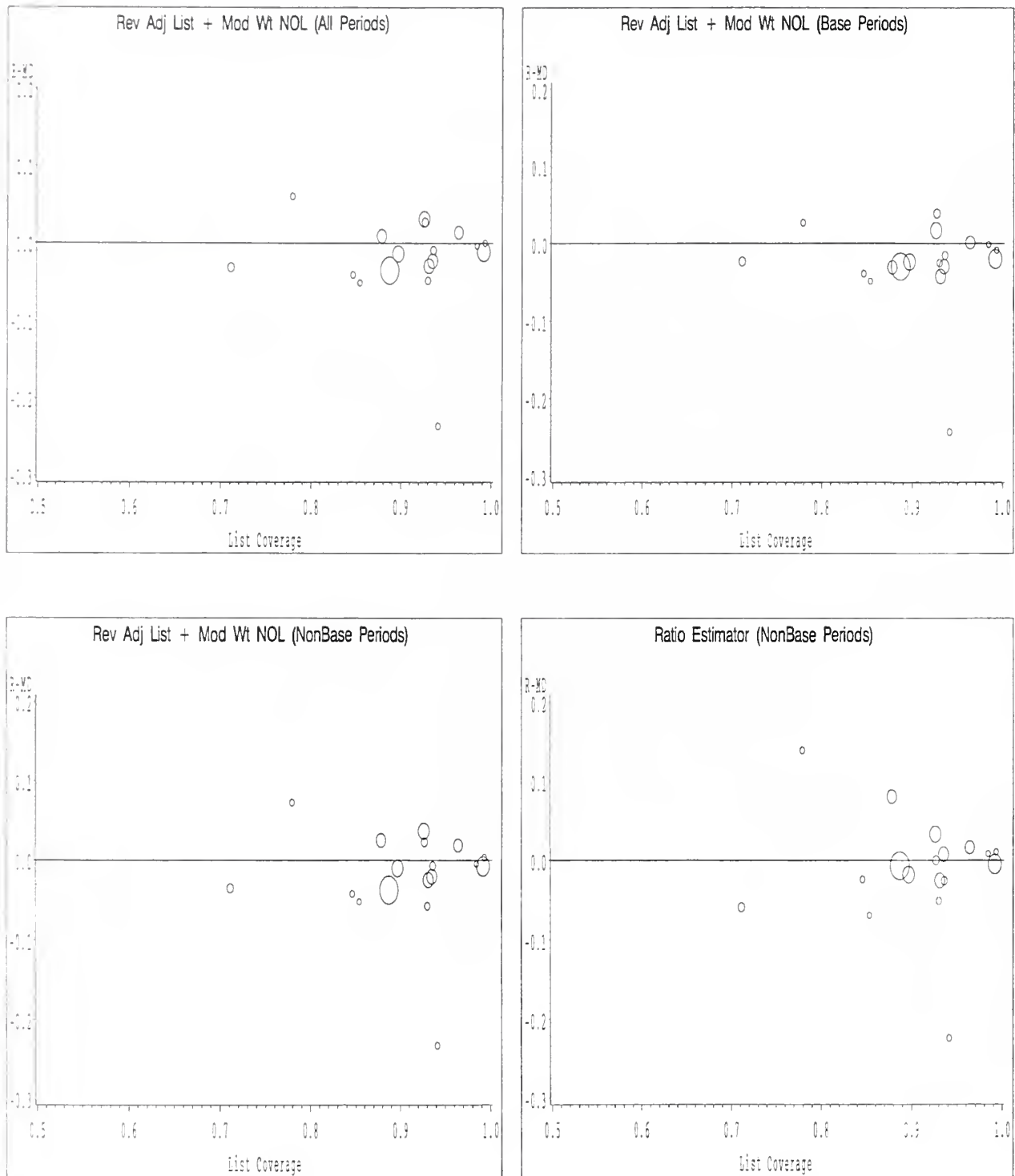
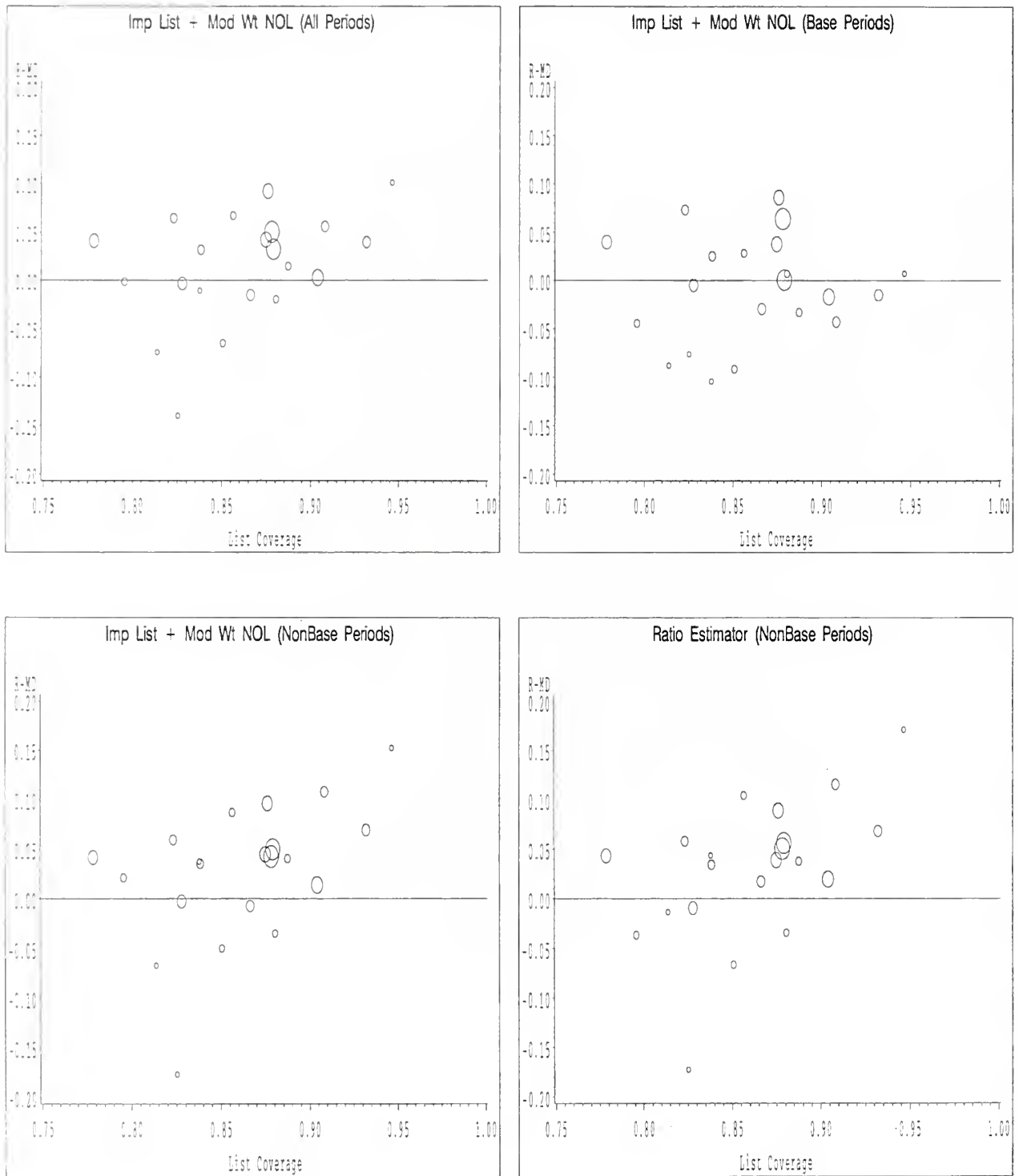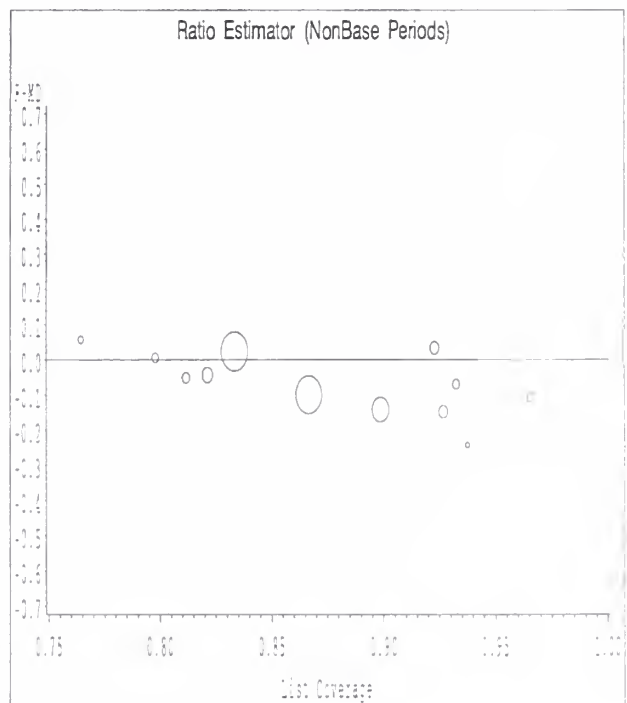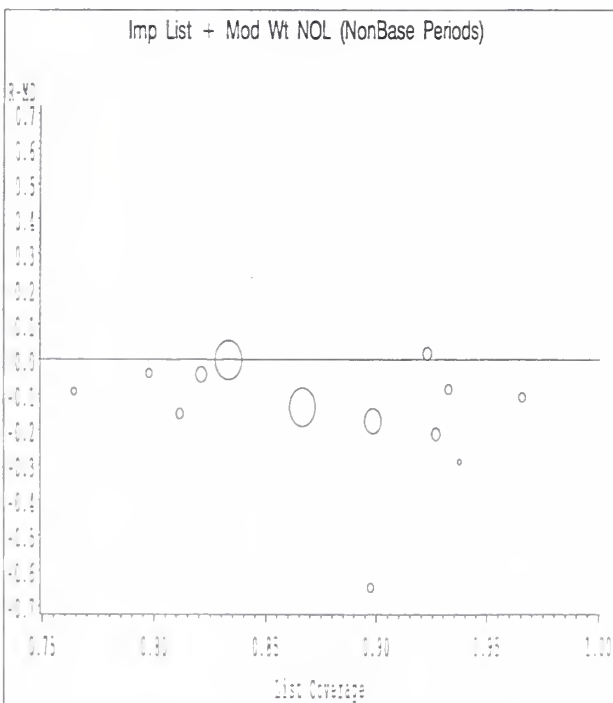# Figure B5: R–MD versus List Coverage
Sows Farrowed: Mar–May (Region)
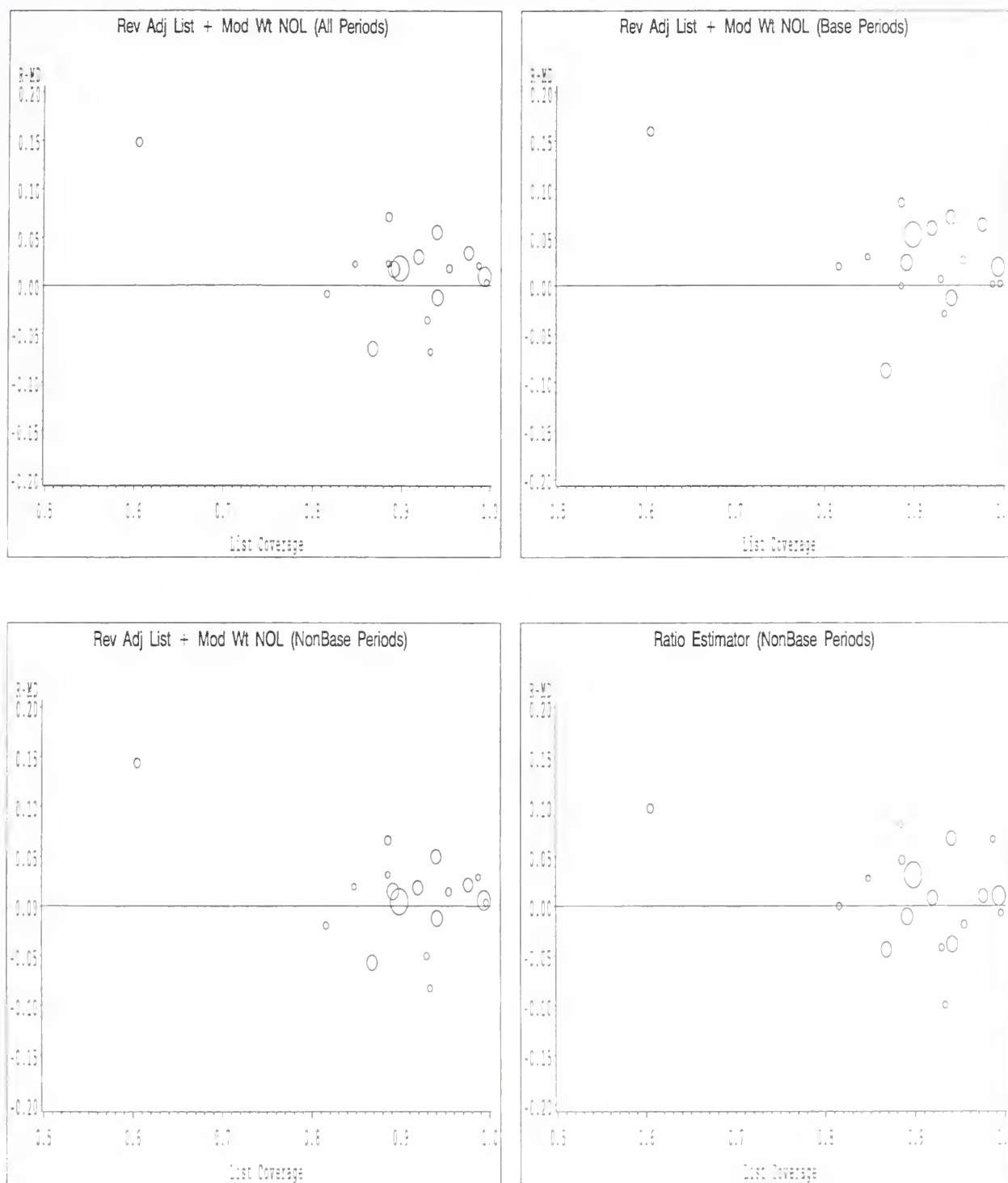
Figure B6: R-MD versus List Coverage
Corn - All Planted Acreage (Region)
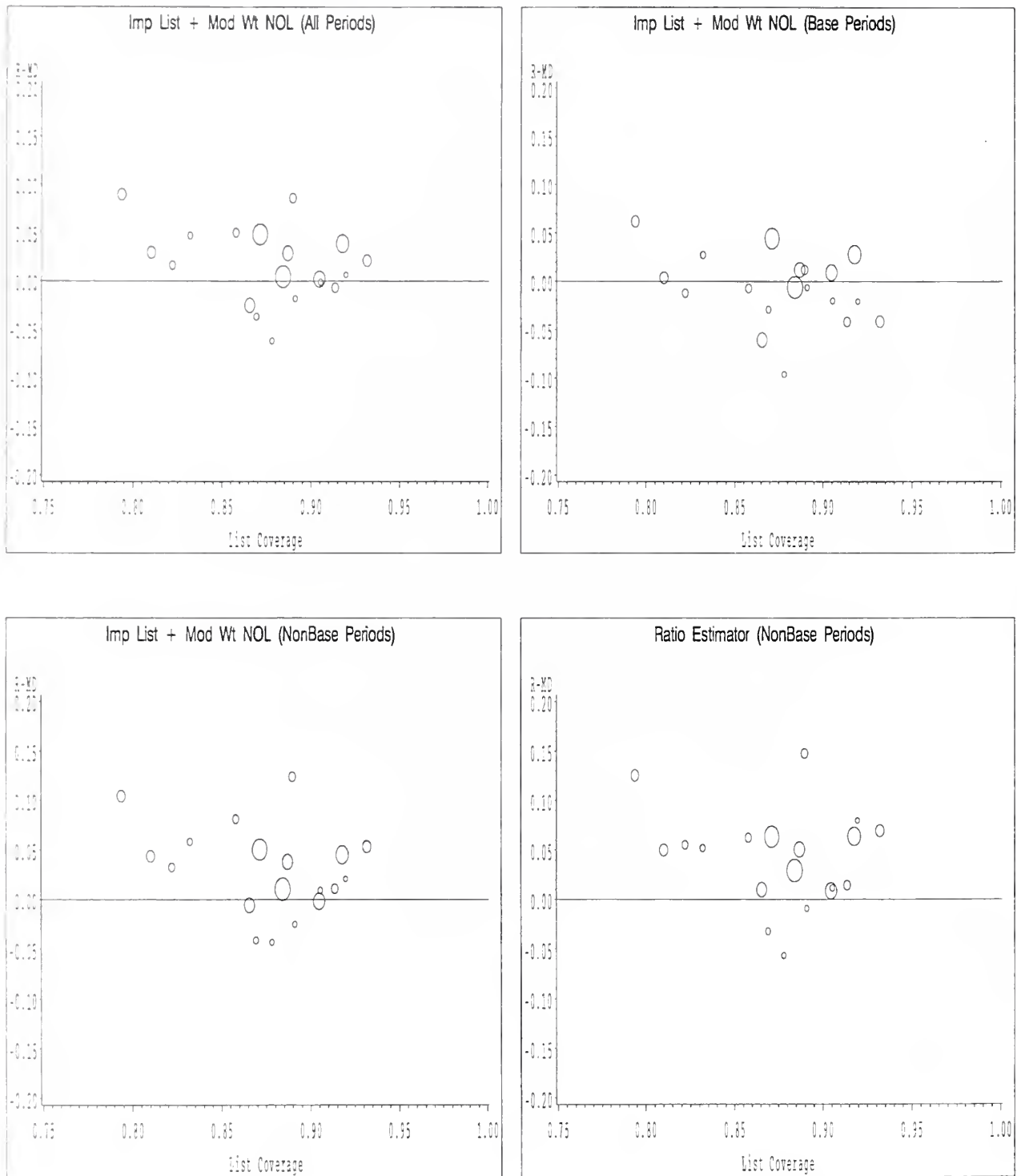
Figure B7: R–MD versus List Coverage
Hay – All Harvested Acreage (Region)

Figure B8: R-MD versus List Coverage
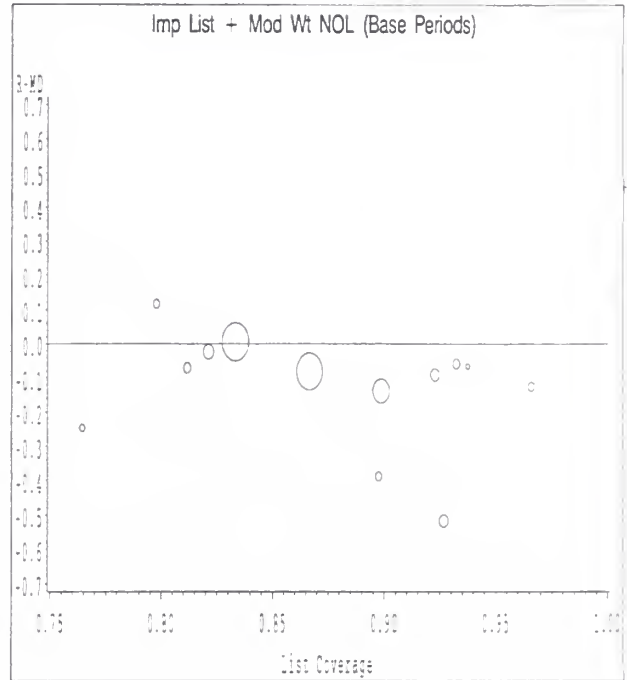## Soybean - All Planted Acreage (Region)

Figure B9: R–MD versus List Coverage
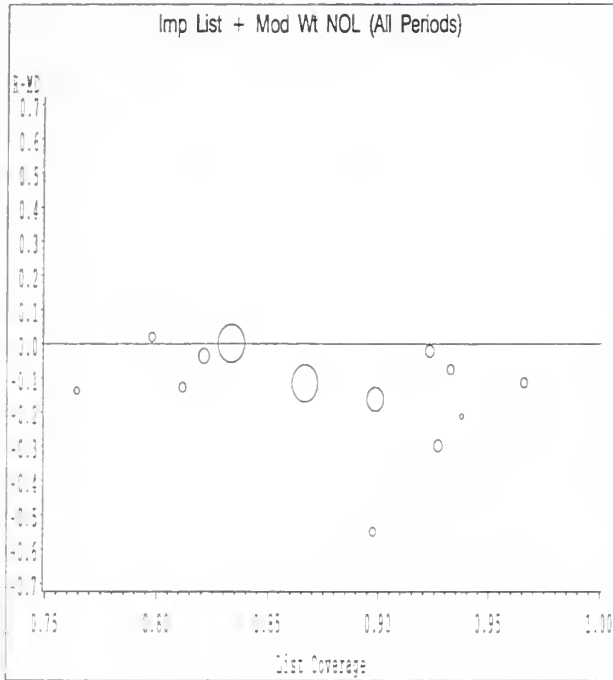## Sorghum – All Planted Acreage (Region)

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Figure B10: R–MD versus List Coverage
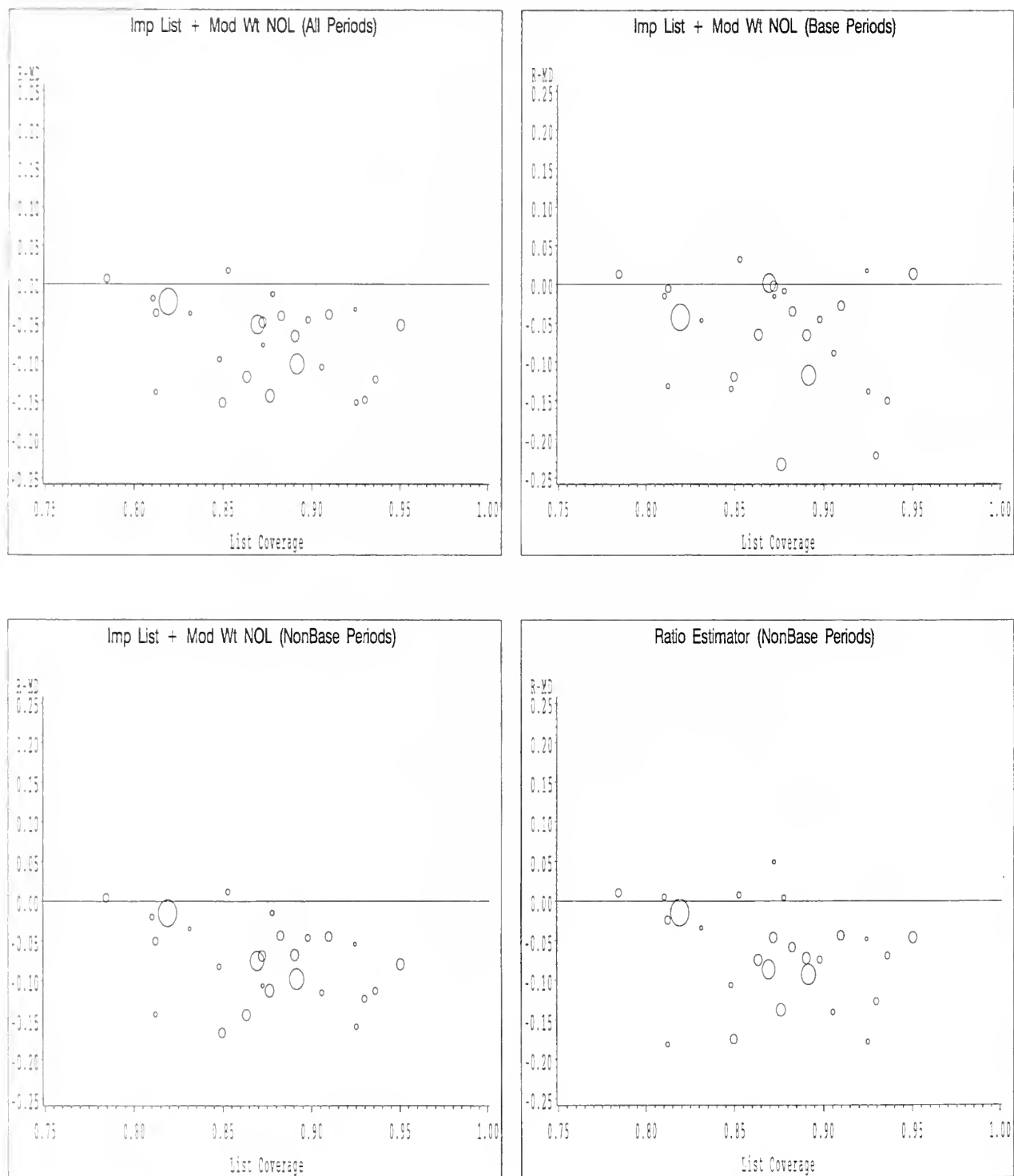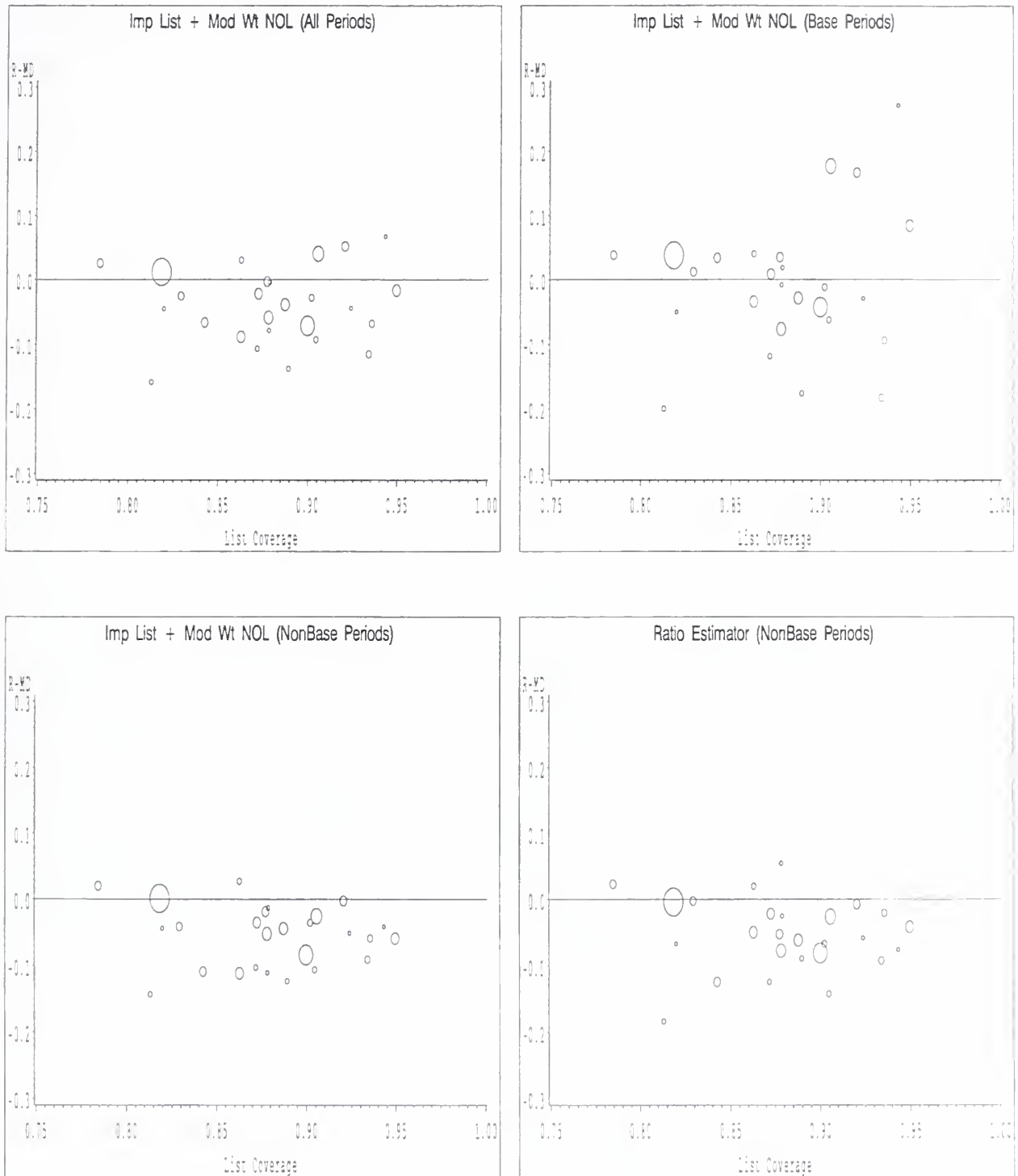## Winter Wheat – All Planted Acreage (Region)

Figure B11: R–MD versus List Coverage
Winter Wheat – All Harvested Acreage (Region)